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M Y

12-1-58	WT 20-304	Secret	1 4	1 (417)
✓ 1-20 <b>-</b> 59	WT 20-306	Secret	3	
< 3-4-59	WT 20-308	Secret	<u>L</u>	- Second
× 8-24-59	WT 20-310	Conf.	4	and the second s
√ 10-7-59	WT 20-311	Secret	<u>L</u>	
12-24-58	WT 20-312	Conf.	L <sub>4</sub>	1.4

Classification Changed to

CONFIDENTIAL

Authority

Authority

Date

12-9-70

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## FORCE AND PRESSURE TEST OF SEVERAL AVCO RE-ENTRY CONFIGURATIONS

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PLOTS  $(\text{Plots of P/P}_{\text{stag}} \text{ and } C_{\text{p}} \text{ vs X/L at } \alpha = \phi = 0 \text{ deg})$ 

Plot No.	Configuration	Mach No.	Grit	Run No.
	111	1.32	No. 36	7
2		2.01		6
3		3.01		5
4		3.98		4
5		5.00	<b>V</b>	3
6	011	1.32	None	12
7		2.01	descriptions	11
8		3.01		10
9		3.98		9
10	161	1.32	No. 36	17
11		2.01	alabatan da	16
12.		3.01		15
13		3.98		14
14	•	4.76		13
15	171	1.32		22
16		2.01		2
17		3.01		20
18		3.98		19
19		4.76	-	18
20	071	4.76	None	23

PLOTS (Cont'd) (Plots of  $C_{p_{b_0}}$ ,  $C_{p_{b_1}}$ ,  $C_{p_{b_2}}$ ,  $C_{p_{b_3}}$ ,  $C_{p_{b_4}}$ , and  $C_{p_{b_5}}$  vs  $\alpha$  at  $\phi$  = 0 deg)

Plot No.	Configuration	Mach No.	Grit	Run No.
21	110		No. 36	36
22		e , * :		33
23				34
24				35
25		3.01		32
26		3.98		31
27		4.76		30
28	010	4.76	None	37

(Plots of (a) 
$$C_L$$
, (b)  $C_D$ , (c)  $C_{m_{cg}}$ , (d)  $C_N$ , (e)  $C_X$ , (f)  $X_{C.P.}$ , and (g)  $-C_{p_{b_0}}$  vs  $\alpha$  at  $\phi$  = 0 deg

29	110	Parameter	No. 36	30-36
30	010		None	37,69,70
31	130		No. 36	38,45,50,56,61
32	030		None	65,68,71
33	140		No. 36	39,46,51,57,62
34	040		None	66,67,72
35	150		No. 36	40,47-49,58,60
36	160			42,43,53,54,64
37	170	V		41,44,52,55,63

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### I. INTRODUCTION

At the request of the AVCO Manufacturing Corporation, Lawrence, Massachusetts, a force and pressure test was performed in the 20-in. Supersonic Wind Tunnel (SWT) of the Jet Propulsion Laboratory (JPL) on models of several re-entry configurations consisting of blunted cone-cylinder combinations with and without boat-tailing.

The objective of the test was to obtain experimental data for use in evaluating theoretical predictions of aerodynamic characteristics and pressure distributions on the various configurations.

The test was performed 1 at Mach numbers 1.32, 2.01, 3.01, 3.98, and 4.76, during the period July 11 through 18, 1958. Mr. Thomas B. Sellers represented the AVCO Manufacturing Corporation.

## II. MODEL DESCRIPTION

Of the six aerodynamic shapes tested, three were run in both force and pressure configurations and three were run in force configurations only. The latter three differed from one another only so far as fins were concerned. All were made up of the same blunted nose cone and cylindrical afterbody. One had no fins, one had thin fins, and the third had thick fins.

The configurations which were run to obtain both force and pressure data fall into two divisions. The first division was composed of two models which again differed only in the fins. The two models were both made up of a blunted nose cone, a cylindrical center

The notation used in this Report is defined in the Nomenclature.

section, and a boat-tailed afterbody. One model had no fins, while the other model had thin fins attached to the boat-tailed section. The second division contained only one model, a basic configuration consisting of a blunted nose cone, a cylindrical center section, and a flared afterbody.

A more detailed description of the six configurations may be found in the Nomenclature, in Ref. 1, in Table 1, and in Figs. 1 and 2. As illustrated by these two Figs., all models were axially symmetric, except for the fins which exhibited a cruciform placement.

### III. WIND TUNNEL AND INSTRUMENTATION

Design features of the 20-in. wind tunnel permit its continuous operation in either a variable-density closed circuit or an open circuit. For the present test, it was operated as a closed-circuit tunnel. Any value of test-section Mach number between 1.32 and 5.00 may be set remotely; however, normal operation is restricted to the 20 Mach numbers between 1.32 and 5.00 for which flow survey calibrations have been made. Operation at other than calibrated Mach numbers is based upon interpolated nozzle settings and, in some instances, partial calibrations. At all Mach numbers, the test section is 20 in. high and 18 in. wide. During a given run, the air supply is maintained at a constant temperature and normally at a dew point sufficiently low to insure that dew-point effects on the data are negligible. The maximum values of dew point at which data were obtained at each Mach number are given in Table 2.

Test-section flow parameters were determined by using the Mach number, the measured supply-section stagnation pressure and temperature, and the assumption of isentropic flow in the nozzle. Table 2 presents a representative value of the test-section flow parameters for Mach numbers at which this test was performed.

Flow in the test section may be observed optically by either the shadowgraph or the schlieren technique. During this test, schlieren photographs were taken at 0, 2, 4, 8, 16, and 20 deg angle of attack.

The six-component hydraulic balance and the model support system used for this test are shown in Fig. 3. The models were sting-supported from the crescent-shaped strut carrier (see Figs. 4 and 5), which may be rotated 30 deg in pitch. The angle-of-attack range was -10 to 20 deg for the straight sting used in this test. The sting and strut carrier are protected from aerodynamic loads by a windshield which is open to the tank surrounding the balance. Flow between the test section and the balance tank is prevented by evacuating the tank to the model base pressure.

The balance system mechanically separates the model lift, drag, and side force and pitching, rolling, and yawing moments. These forces and moments are sensed by hydraulic load cells and are measured by self-balancing beams. The moments as measured are referred to a set of orthogonal axes which intersect at a point that is coincident with the center of rotation of the support system and the centerline of the test-section windows.

The range and repeatability of the balance are shown in Table 3.

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For eight of the configuration 110 runs during the force portion of the test, a model-base-pressure rake was attached to the windshield (see Fig. 6) in such a manner that five base pressures were measured at various distances from the center of the model base immediately aft of the base plane. These five pressures were sensed by a single transducer which measured each pressure in turn. These data were eventually read manually from a potentiometer indicator and punched into paper tape.

During all the force runs, a single base pressure tap was monitored to insure equity between model base pressure and balance tank pressure, as mentioned earlier in this section.

Although three aerodynamic shapes were pressure tested, only two models had to be instrumented since configuration 171\* is evolved simply by removing the fins from configuration 161. A total of 26 body static and 5 fin base pressures were measured on configuration 161, and all but the 5 fin base pressures were measured on configuration 171. The other pressure model, configuration 111, incorporated 40 body static taps. All pressures were sensed and recorded by a multipressure measuring system whose main components include an accurate strain-gauge type pressure transducer, multitap pressure selector valves, and a high speed encoder with punched paper tape recording (see Fig. 7).

<sup>\*</sup>See Model Nomenclature in the Nomenclature section of this Report.

#### IV. TEST PROCEDURE

Prior to actual test operations, measurements were made to determine the position of the model, the deflection constants, and the balance tares, as described in Section V.

During the force portion of the test, the balance tank pressure was maintained equal to the model base pressure, and data points were obtained at successive values of angle of attack. The stagnation pressure and model base pressure were recorded for all data points, and the stagnation and dew-point temperatures were read at least once each run. Balance readings were plotted vs angle of attack, and any data which appeared questionable were checked before the conclusion of the run; but even if all of the data appeared to be correct, at least one point from each run was checked. Schlieren photographs were made only during the force portion of the test and at the angles of attack mentioned in Section III. Typical examples are illustrated in Figs. 8, 9, and 10.

Since the multipressure measuring system used in this test was at that time a comparatively new piece of equipment, a mercury manometer board displaying the model pressures being measured was photographed at zero angle of attack during each pressure run. However, the accuracy and reliability of the new system proved to be such that the photographic data were not used in the reduction described in Section V.

The test was conducted in the order shown in Table 4.

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### V. DATA REDUCTION

The force and moment data were reduced (see Ref. 2) to dimension-less coefficients and are presented with respect to a model reference point and in two coordinate systems (see Fig. 11), specified by the AVCO Manufacturing Corporation. The model reference point was taken as the vehicle center of gravity which varied with configuration, as shown in Table 1. The pitch axis system is an orthogonal set of axes which have their origin at the model reference point and which rotate with the model in pitch and yaw, but remain fixed in roll. The tunnel wind axes are identical to the pitch axes, except that they remain fixed with respect to the tunnel.

Linear expressions derived from the deflection measurements (see Section IV) were used to determine the actual position and attitude of the model for each test point.

Three types of corrections were applied to the data, as follows:

- In order to compensate for zero drift during the test, air-off readings with the model level were taken at frequent intervals. These air-off-zeros were then subtracted from the test data to determine values due only to aerodynamic loads.
- 2. Static tares, produced by unbalanced weight in the system with no air flow through the test section, were evaluated by setting the model to the attitudes to be experienced during the test and recording the balance readings. These readings were subsequently subtracted from the readings obtained during the test.

3. During each run, the balance tank pressure was very closely matched with the model base pressure, as discussed in Section III. Where a descrepancy between the two pressures did exist, a term was added to the data reduction to eliminate any error arising therefrom.

The repeatability of the data in coefficient form is given in Table 5. Three alpha-zero data points in each run were compared with one another to determine the greatest failure of the data to repeat itself. The figures in Table 4 represent the worst ability to repeat, after ignoring 2 or 3 wild values, for each component measured at each Mach number.

The following equations were used in the reduction of the data:

$$C_{N} = N/qA$$

$$C_{X} = F_{X}/qA$$

$$C_{m_{cg}} = M/qAd$$

$$X_{c.p.} = X_{cg} - C_{m_{cg}}/C_{N}$$

$$C_{L} = L/qA$$

$$C_{D} = D/qA$$

$$C_{P_{b_{1}}} = (P_{b_{1}} - P_{s})/q$$

$$P/P_{stag} = P/(P_{t_{2}}/P_{t_{1}})P_{t}$$

$$C_{P} = (P - P_{s})/q$$

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where

$$P_{s} = (P_{s}/P_{t})P_{t}$$
$$q = (q/P_{t})P_{t}$$

A = cross-sectional area of model body cylinder, 3.457 in.<sup>2</sup>

 $d = model body-cylinder diameter, 2.098 in.^2$ 

i = a number from zero through five which indicates the radial position of any one of six base pressure taps (see Fig. 7).

#### VI. RESULTS

The information obtained during the test is presented in three groups of plots as shown in the plots section (see Plots 1 through 37g). The first group contains Plots 1 through 20 in which P/P<sub>stag</sub> and C<sub>p</sub> are plotted vs the model length ratio X/L. Group two is composed of Plots 21 through 28 in which C<sub>p</sub>, C<sub>p</sub>, C<sub>p</sub>, C<sub>p</sub>, C<sub>p</sub>, C<sub>p</sub>, C<sub>p</sub>, and C<sub>p</sub>, are plotted vs angle of attack. The third group contains nine families of plots, numbered 29 through 37. Each family, in turn, contains Plots a through g which are, respectively, C<sub>L</sub>, C<sub>D</sub>, C<sub>mcg</sub>, C<sub>N</sub>, C<sub>X</sub>, X<sub>c.p.</sub>, and C<sub>p</sub>, vs  $\alpha$ .

Figures 12 through 15 are summary plots which illustrate \*ypical effects of Mach number, configuration, and roughness (to induce boundary layer transition) on model pressures, lift, drag, pitching moment, and center of pressure location.

No attempt to analyze the data is made here. Copies of the plots and prints of the schlieren photographs were forwarded to the AVCO Manufacturing Corporation, and a detailed analysis will be performed there.

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## REFERENCES

- 1. Sellers, T. B., <u>Wind Tunnel Pre-Test Report for the Jet Propulsion</u>
  <u>Laboratory 20-in. Supersonic Wind Tunnel</u>. AVCO Manufacturing
  Corporation, Lawrence, Massachusetts, May 22, 1958.
- 2. Equations for Wind Tunnel Force Data Reduction, Internal Memorandum SWT G-T3. Jet Propulsion Laboratory, Pasadena, California, April 19, 1957.

#### NOMENCLATURE

# Data Reduction Nomenclature<sup>2</sup>

 $A = reference area, 3.4570 in.^2$ 

 $C_D = drag$  force coefficient, D/qA

cg = defined model center of gravity

 $C_1$  = lift force coefficient, L/qA

 $C_{m_{CQ}}$  = pitching moment coefficient, M/qAd

 $C_{N}$  = normal force coefficient, N/qA

 $C_{p}$  = model local static pressure coefficient,  $(P - P_{s})/q$ 

 $C_{P_{b_i}}$  = model base pressure coefficient,  $(P_{b_i} - P_s)/q$ 

 $C_X$  = chord force coefficient,  $F_X/qA$ 

d = reference length, 2.098 in.

D = drag force (not corrected for base pressure), lb

 $F_{\chi}$  = chord force (not corrected for base pressure), lb

i = a subscript number from 0 thru 5, which indicates the
 radial position of any one of six base pressure taps (see
 Fig. 7)

L = lift force, lb

M = Mach number

M = pitching moment, in.-lb

N = normal force, lb

 $P = model local static pressure, lb/in^2$ 

 $P_{b_i} = model base pressure, lb/in^2$ 

<sup>2</sup>Positive directions for force and moment coefficients are given in Fig. 11.

## NOMENCLATURE (Cont'd)

 $P_s = \text{free-stream static pressure, } 1b/\text{in}^2$ 

 $P_{stag}$  = test-section stagnation pressure behind a normal shock wave, lb/in.

 $P_{+}$  = tunnel supply section total pressure,  $lb/in^{2}$ 

 $P_{t_2}/P_{t_1}$  = ratio of total pressure behind a normal shock wave to total pressure before the normal shock wave

 $q = free-stream dynamic pressure, <math>lb/in^2$ .

 $X_{cg}$  = model center of gravity location, inches aft of nose

 $X_{C.P.}$  = center of pressure location, inches aft of nose

 $X/L = ratio\ of\ pressure\ tap\ distance\ aft\ of\ nose\ to\ total\ model$  length

 $\alpha$  = model angle of attack, deg

 $\varphi = model roll angle, deg$ 

## Model Nomenclature<sup>3</sup>

$$N_a^b$$
  $B^c$   $F_e^d$  or  $N_a^b$   $B_B^c$   $f^g$ 

N = nose configuration

a = nose radius in cylinder radii

b = nose cone angle in deg

B = cylindrical body

c = cylinder length in cylinder diameters

B = boat-tailed afterbody

 $<sup>^3</sup>$ See Figs. 1 and 2 for illustrations of models.

# NOMENCLATURE (Cont'd)

F = flare

d = flare angle in deg

e = flare length in cylinder diameters

f = fin

g = fin thickness in cylinder diameters

# Configuration Nomenclature

Configuration	Code	Explanation
N <sup>11</sup> B <sup>1.5</sup> F <sup>15</sup> 0.80	X10	<pre>(1) First digit indicates     roughness:         1 = grit applied         0 = grit removed</pre>
$N_{0.3}^{11}B^{1.5}F_{0.80}^{15}$	X11	
N <sup>11</sup> <sub>0.3</sub> B <sup>3.0</sup>	X30	(2) Second digit indi- cates aerodynamic configuration, as in table at left
$N_{0.3}^{11}B^{3.0}f^{0.07}$	X40	
N <sub>0.3</sub> B <sup>3.0</sup> f <sup>0.71</sup>	X50	<pre>(3) Third digit indicates    instrumentation:         1 = pressure         0 = force</pre>
$N_{0.3}^{11}B_{B}^{3.0}f^{0.07}$	X60	
N B B 3.0 f 0.07	X61	
N <sub>0.3</sub> B <sub>B</sub> 3.0	X70	
N <sub>0.3</sub> B <sub>B</sub> 3.0	X71	

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TABLE 1. MODEL DIMENSIONS

Configuration Code	X11 X10	X30	X40	X50	X61 X60	X70 X71
Length		Agramma validellis Agram, vannas ellaspanisassionnin ingerysjanispassion vannas ellaspassionnin vannas ellaspanisassionnin ingerysjanispassionnin ingerysjanisp				
Overall	8.742	10.102	10.102	10.102	10.102	10.102
Nose	3.914	3.914	3.914	3.914	3.914	3.914
Cylindrical Body	3.145	6.188	6.188	6.188	6.188	6.188
Flare	1.683	\$100\$ 1959 well yeld: bloom	ages 4050 falor 41.00 445a	while spins was name while	6059 10000 10000 61000 00100	MATER STORE WINDS WARRY MATER
Boat-tail	NORTH MANERS SALVAN SALVAN PROPERTY	Hith this thick date date	HETER MENTS MADE WATER THOMAS	days down seems readle strong	2.098	2.098
Fin	come essab come saque equip.	majo espet moto espet écolo	2.098	2.098	2.098	elekt mine melgi noggi ngoji.
Diameter			dia atamin'ny fivondrona na anana ana ang kamin ng katang ang kanana ang kanana ang kanana kanana ang kanana k I			
Cylindrical Body	2.098	2.098	2.098	2.098	2.098	2.098
Flare Base	3.000	econic ricono eccesa assista assista	1958 1858 4650 4650 30be	dente decore solde solde delte.	Marin Applic 60000 SMSsy solden	TACES GARGE GRADE SECTION SECTION
Boat-tail Base	HONG MOTE GOTO DATE VISE	World place orgal eagly spale	গাড়িক আমত বৰ্ডৰ প্ৰৱাধ ক্ৰমত	quinto accione applica della d	1.049	1.049
Radius					ументверине в постанительного в почет в расправного почет в по	атим на при на при На при на при
Nose	0.349	0.349	0.349	0.349	0.349	0.349
Fin Base (at Fin G	their entire ether 8744	15pP Bline Wildo Anno Moha	1.574	1.504	1.574	9000 4000 \$200 palm story
Thickness			en normanise grant de entre france en grant de entre france en grant de entre france en grant de entre france e		1999 (Park All Marcos California and California (Series and Series and Series and Series (Series and Series and Series and Series and Series (Series and Series and S	et foresten et all sold som a som promoter som et anne
Fin	ব্যক্ত অধাৰ অধ্যয় ৰাজ্যৰ ব্যক্ত	gladin opsina derne tessene andere	0.140	1.483	0.140	SSQR-8646 5004 8000 8000
Conical Half Angle	Material Committee (Committee) and a second state of the committee (Committee) and a second state of the commi					
Nose	1.	l l	The state of the s	g consideration and the constraint of the constr	To the second se	11
Flare	15	Manager entering the control of the	9956 HIGH	Septe strips	-10006 G0496	divides polys
Boat-tail	TOPO MILA	envery equic.	dono regina	coner mass.	14	14

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TABLE 1 (Cont'd)

Configuration Code	X10 X11	х30	X40	X50	X60 X61	X70 X71			
CG Location									
Aft of Nose	5.979		5.612	5.612	5.612	5.612			

Consult Ref. 1 for pressure port locations.

All dimensions in deg and in model scale in. and in  $\stackrel{?}{.}$ ; no scale given; see Configuration Nomenclature and Fig. 2.

TABLE 2. AVERAGE AERODYNAMIC PARAMETERS

	Mach Number							
Parameter	1.32	2.01	3.01	3,98	4.76			
Static pressure (psia)	7.00	3.26	0.78	0.33	0.16			
Stagnation pressure (psia)	20.22	26.00	28.89	49.11	63.56			
Dynamic pressure (psia)	8.76	9.24	4.92	3.76	2,53			
Reynolds number (per in. x 10 <sup>-6</sup> )	0.475	0.500	0.338	0.337	0.287			
Max dew point (°F)	+4	+3	+4	+8	+12			
Mach-number variation along centerline	+0.002	+0.004	+0.003	+0.005	+0.004			
Max flow-angle variation along centerline deg	+0.02	+0.08	+0.08	+0.13	-0.01			
Max pressure variation along centerline (Δp/p)	0.004	0.006	0.006	0.007	0.010			

TABLE 3. BALANCE KANGE AND REPEATABILITY

Section 2015 and a section of the se		Low Range		High Range				
Component	Maximum Positive	Maximum Negative		Maximum Positive		Repeat- ability		
Lift (lb)	52	12	±0.05	320	120	±0.2		
Drag (lb)	25	20	±0.05	225	325	±0.2		
Side force (lb)	30	30	±0.05	30	100	±0.2		
Pitching moment (inlb)	325	425	±0.50	3500	1100	±2.0		
Yawing moment (inlb)	200	440	±0.50	1800	2500	±2.0		
Rolling moment (inlb)	440	200	±0.50	2800	2000	±2.0		

TABLE 4. RUN SUMMARY

				-				
Date (1958)	Run No.	Configuration Code	Mach No.	a (deg)	Grit	Pb	Rake	Remarks
7-11	- Personal	110	AND	Store	Adapting	No.	way	Static tare
7-11	2	130	mpi	96.04	199544	qualit	20049	Sta <b>tic</b> tare
7-14	3	111	5.00	В	No. 36	Off		
-pirita-primata	4	L. Marie Carlos Car	3.98	-nh Windalaysia	Alexandria (Color)		TO THE STATE OF TH	
	5		3.01	della communicación de la que			An in Anna Anna Anna Anna Anna Anna Anna	
	6		2.01				of proper in management of the contract of the	
	7	•	1.32		V		CONTRACTOR	
	8	011	5.00		None		wdox	No data; no flow
	9		3.98		The property of the control of the c		erelisiökenilmesamesamesamesamesamesamesamesamesamesa	
	10		3.01					
	11		2.01					
<b>\</b>	12	•	1.32		V	State of the state		
7-15	13	161	4.76		No. 36			
Hiddan	14	POTENTIAL PROPERTY OF THE PROP	3.98					
PATRICAL COLOR COL	15		3.01					
ажістар жана адамістар	16		2.01	Maria and the state of the stat			and the second s	
	17		1.32					
	18	171	4.76	Annual and an age of the second			WHATELERAD AND ADD 1/2 and	
standous representativos	19	OF THE PROPERTY OF THE PROPERT	3.98	**POOP********************************			A public purceyone stage management	
er ette obstante med en	20		3.01	Andrew control of the second		THE STATE ST	dish assir dalakanilan dana ya	
	21		2.01					
tenente en enciclo de describir.	22		1.32	THE ADDRESS OF THE AD		management of the second of th	oleydgynamyda, hono disa	
	23	071	4.76	W	None	V	microlemanuschiologic bookbaas	

TABLE 4 (Cont'd)

							*	
Date (1958)	Run No.	Configuration Code	Mach No.	(deg)	Grit	P <sub>b</sub>	Rake	Remarks
7-15	24	130	20120	4369	WEIGH.	460	VIII	Static tare
anauth grave	25	160	Market in the second se	Market	9552	98498	4000 A000	Static tare
намоди-сневаю (пован-	26	150	.000	Appel	Total Security	Mon		Static tare
Polyphophological	27	140	order order	TORS TO STATE OF THE STATE OF T	NO.00	esado	10000000000000000000000000000000000000	Static tare
picosocicio de la compania del compania del compania de la compania del la compania de la compania dela compania del la compan	28	170	de de la companya del companya de la companya del companya de la companya del companya de la companya de la companya de la companya del companya de la companya del companya de la companya de la companya de la companya de la companya del companya de la companya de la companya de la companya de la companya del companya del companya del companya de la	ema-	- California de la cali	2009	Allower	Static tare
	29	110	Numer	and the state of t	wage	oust	1000	Static tare
7-16	30	ALT COMMON CONTRACT OF THE CON	4.76	A	No. 36	On	disagnitive de la constante de	
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TABLE 4 (Cont'd)

	*	The state of the s		7 (00				
Date (1958)	Run No.	Run Configuration		a (deg)	Grit	Pb	Rake	Remarks
7-17	46 140		3.98	А	No. 36	Off		
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	48	150	3.01			inderen venne oudinous		
	49	<b>1</b> 50						
	50	130				POTENTIAL AND		
	51	140						
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	53	160					and and a second a	
	54	160	1.32				Administration of the state of	Data question- able
	55	170	**************************************				4009	Data question- able
	56	130					67496	Data question- able
	57	140				destruction destru		
	58	150					and the second s	
	59	120	wegos	6400	959-	map .	engs.	Static tare
7-18	60	150	2.01	А	No. 36	Off	en hande de l'adoc en construcción de l'adoc	
	61	130		**************************************		-	and the second s	
	62	140					dentina and and and and and and and and and a	
	63	170					Andida Shaqada, Ingga maga	
	64	160					entrempe communication programmers	
	65	030	THE PARTY OF THE P		None		sanchamananna mana	
	66	040			None		MPHAPTORONOLA MARTINAPINA	
					Albania de Sala de Carlos	MANAGEMENT PROVIDES ASSESSED.		

TABLE 4 (Cont'd)

Date (1958)	Run No.	Configuration Code	Mach No.	α (deg)	Grit	P <sub>b</sub>	Rake	Remarks
7-18	67	040	1.32	А	None	Off	anazanovný manažiný úžáklých	
***************************************	68	030	age alone across time	А			Aggregation of the state of the	
	69	010		40.7%			Booms	Special a schedule
	70	010	4.76	A			The second secon	Repeat of run 37
	71	030		evening delighted in an extension makes				
	72	040						

 $\alpha$  Schedule A: 0, -4, -2, 0, 2, 4, 8, 12, 16, 20, and 0

 $\alpha$  Schedule B: 0, -10, -5, 5, 10, 15, and 20

TABLE 5. COEFFICIENT REPEATABILITY

Mach	Coefficient <sup>C</sup>						
No.	C <sub>L</sub>	$C_{\mathcal{D}}^{D}$	C <sub>D</sub> <sup>a</sup>	Cb mcg			
1.32	0.008	wip	0.009	0.008			
2.01	0.006	- NA-60	0.009	0.008			
3.01	0.006		0.012	0.008			
3.98	0.008	0.003	9966	0.011			
4.76	0.012	0.002	4000	0.015			
4.76d	0.023	0.006	0.023	0.027			

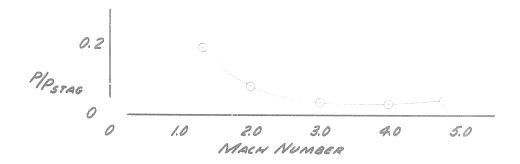
<sup>a</sup>High balance range used.

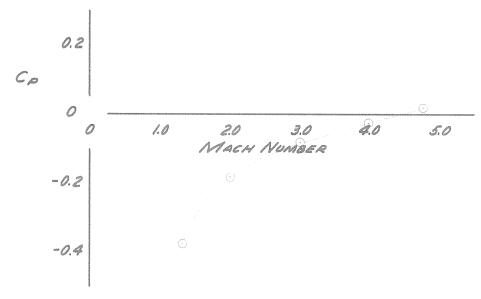
bLow balance range used.

cBased upon the following reference areas and lengths:  $S = 3.457 \; \text{in}$ , and  $d = 2.098 \; \text{in}$ .

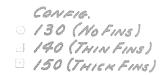
 $\ensuremath{\text{d}}\xspace_Based$  upon the Table 3 balance repeatability for the appropriate range used and the reference values given in footnote c, above.

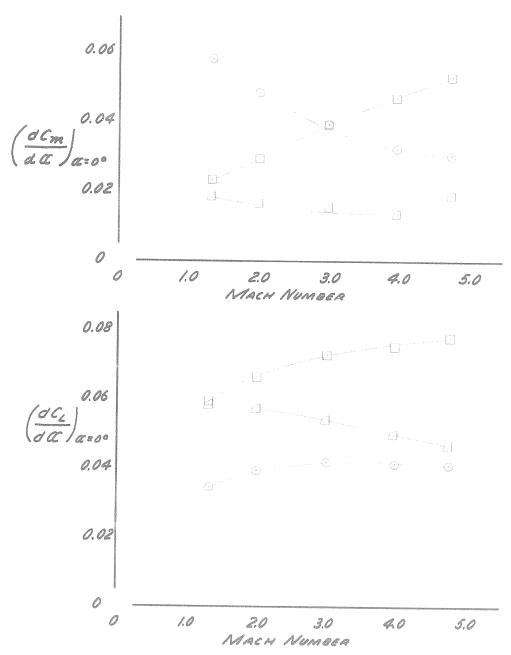
X/L = 0.827 CONFIG. - 161





EFFECT OF MACH NUMBER ON P/PSTAG AND CP FOR CONFIGURATION 161 AT X/L = 0.827, C=0°, WITH ROUGHNESS

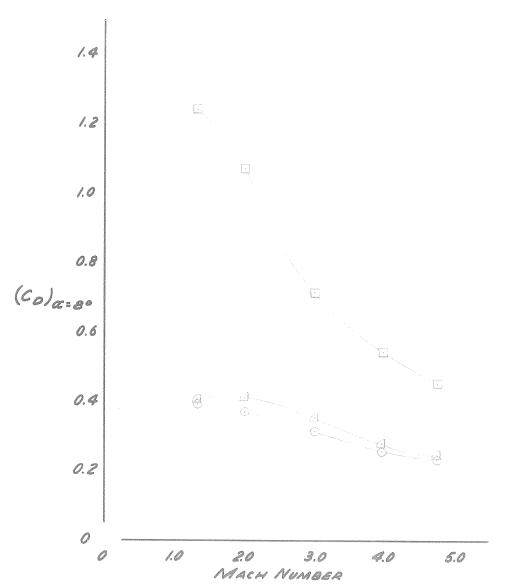




EFFECT OF MACH NUMBER AND CONFIGURATION UPON LIFT CURVE SLOPE AND PITCHING MOMENT CURVE SLOPE AT Q=0°, Q=0°, WITH ROUGHNESS



- 130 (No FINS)
- 140 (THIN FINS)
- 150 (THICK FINS)



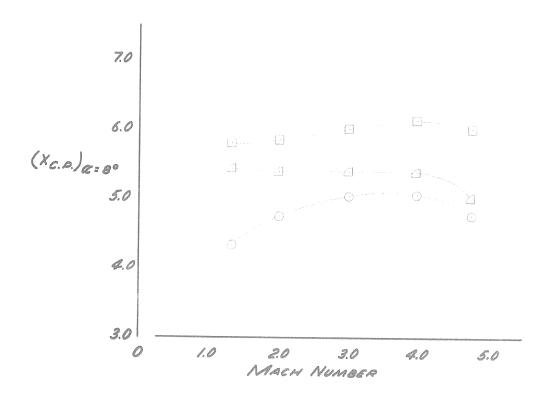
EFFECT OF MACH NUMBER AND CONFIGURATION UPON DRAG COEFFICIENT AT CE-8°, \$ = 0°, WITH ROUGHNESS

CONRIG.

130 (NO FINS)

140 (THIN FINS)

150 (THICK FINS)



EFFECT OF MACH NUMBER AND CONFIGURATION UPON CENTER OF PRESSURE LOCATION AT C=8°, 0=0°, WITH ROUGHNESS

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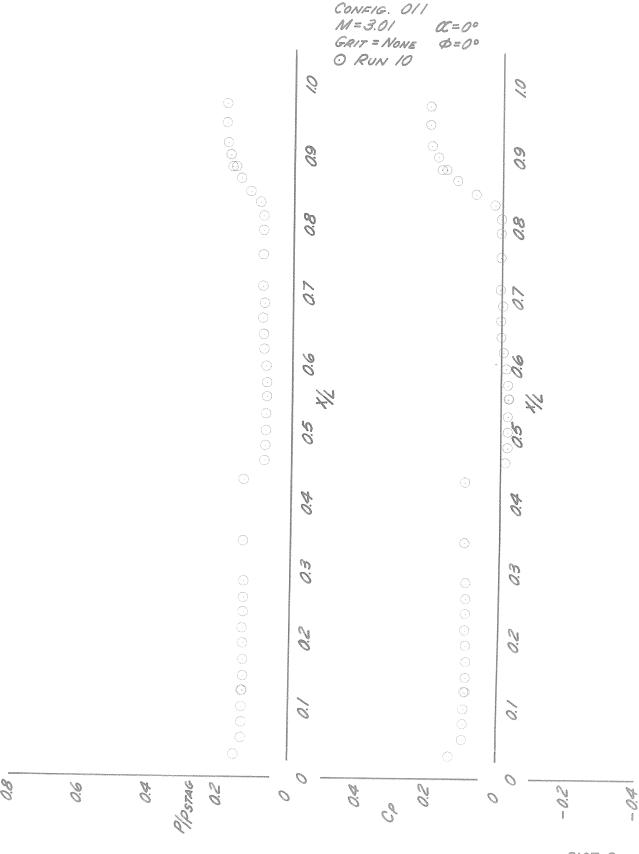
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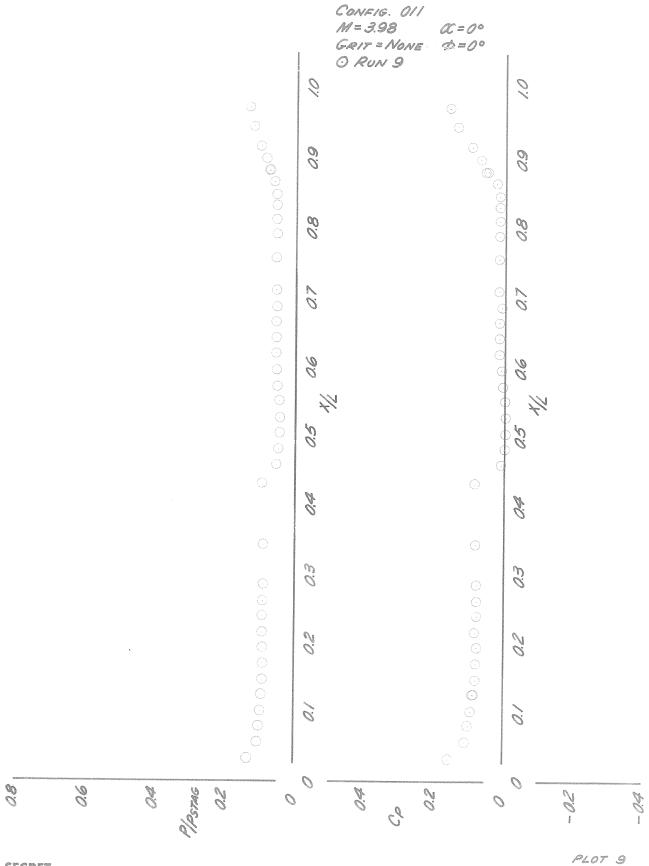
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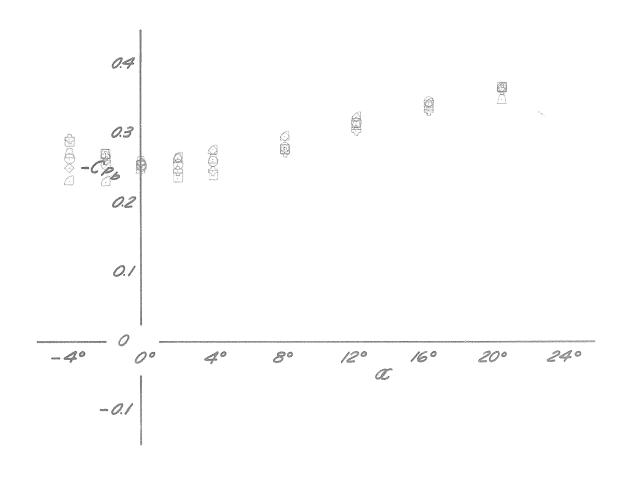
PLOT 19

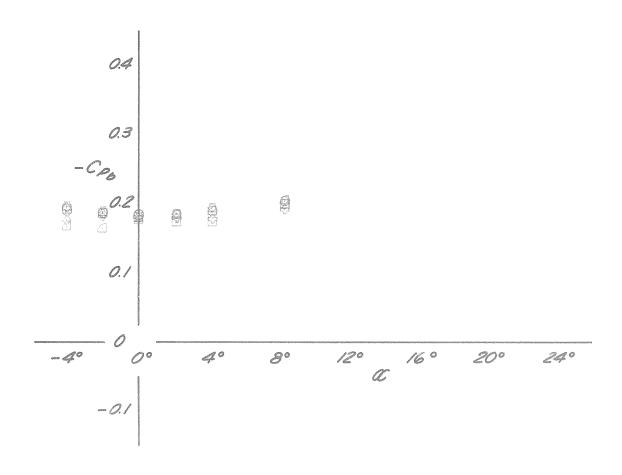
M G	ONFIG.  7   =4.76  RIT #36   RUN  8	α=0° φ=0°				
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CONFIG. 110
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GRIT #36 Φ=0°
RUN 36

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○ CP62
△ CP63
♣ CP64
□ CP65





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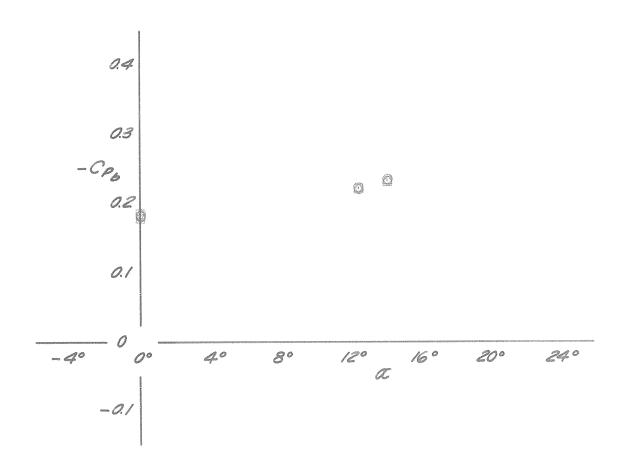
CONFIG. 1/0

M = 2.01

GRIT #36 \$\phi = 0^\circ

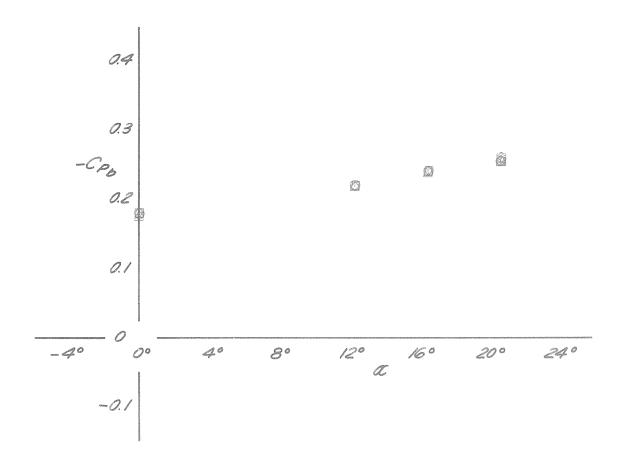
RUN 34

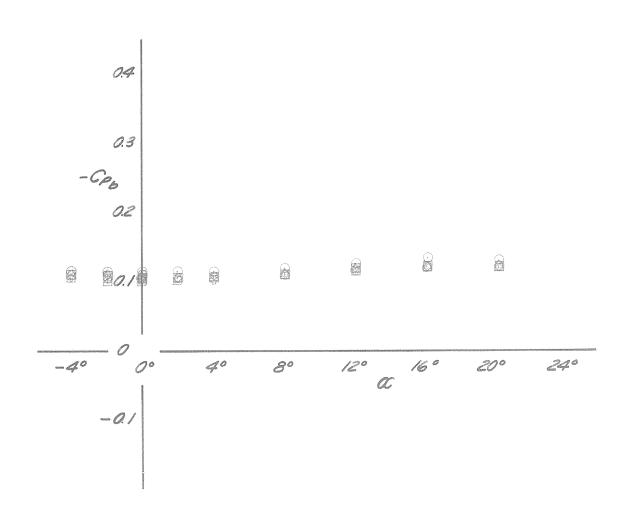
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○ CP61
○ CP62
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♣ CP64
□ CP65

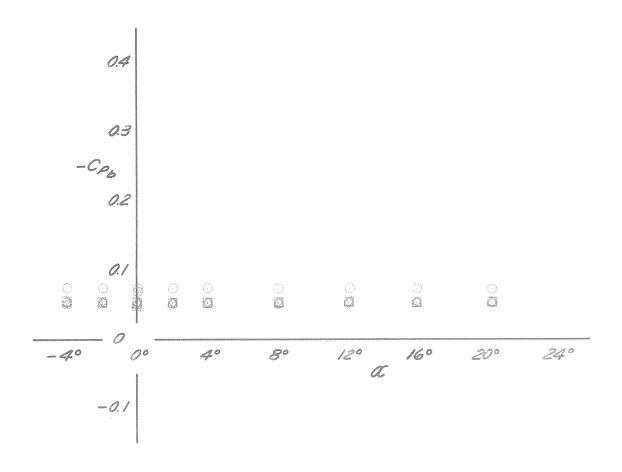


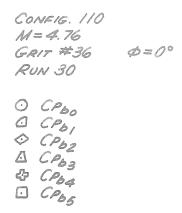
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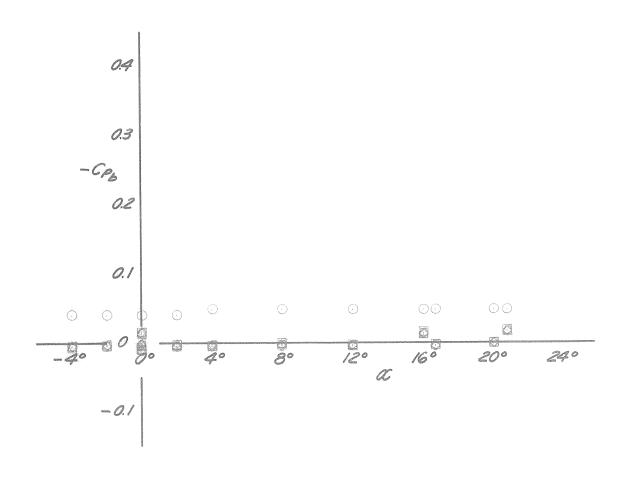
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 ◇ CP62
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 ❖ CP64
 □ CP65

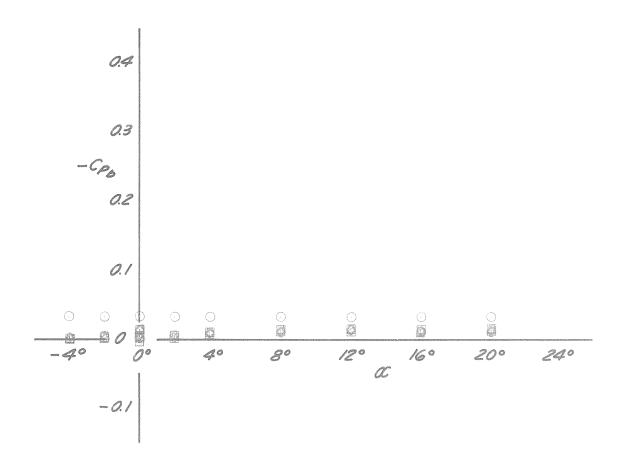


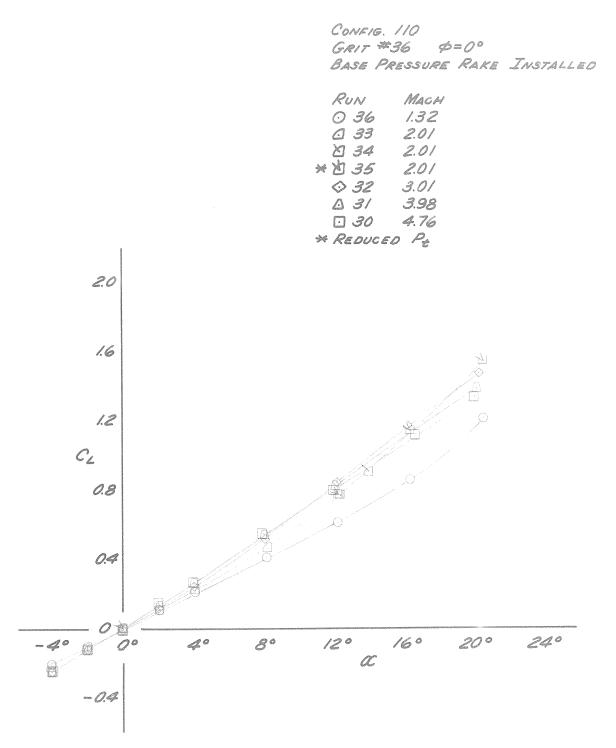


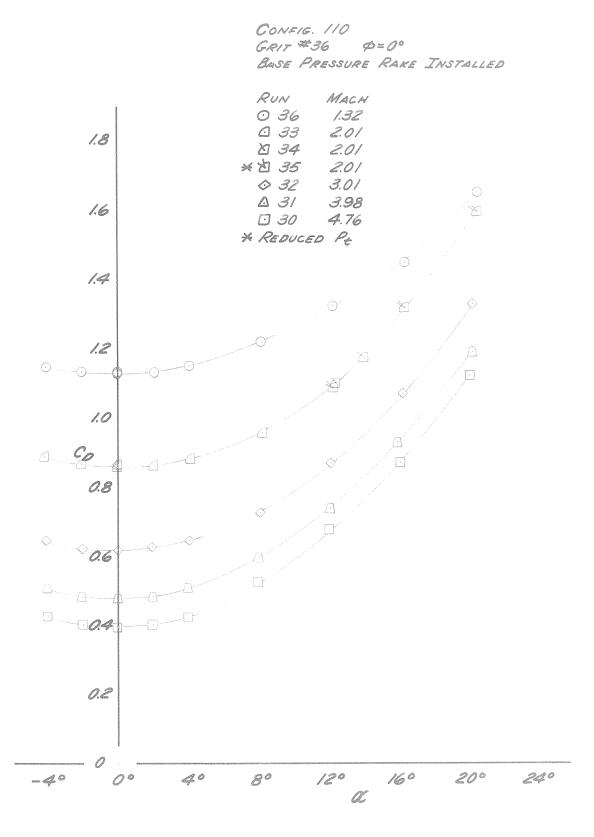










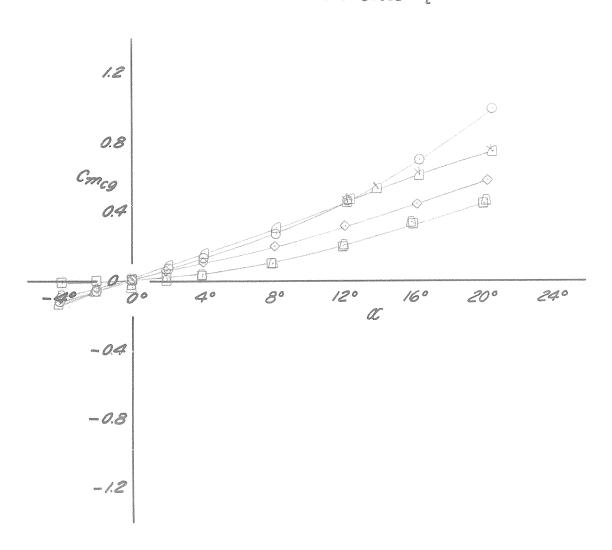


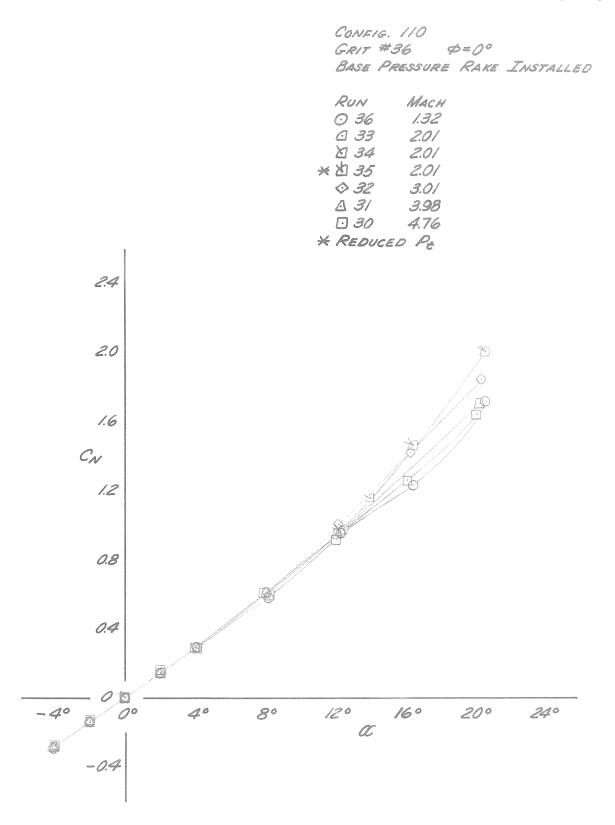
CONFIG. 110 GRIT #36 Ø=00 BASE PRESSURE RAKE INSTALLED MACH RUN 036 1.32 *a 33* 2.01 **134** 2.01 ※也35 2.01 3.01 ♦ 32

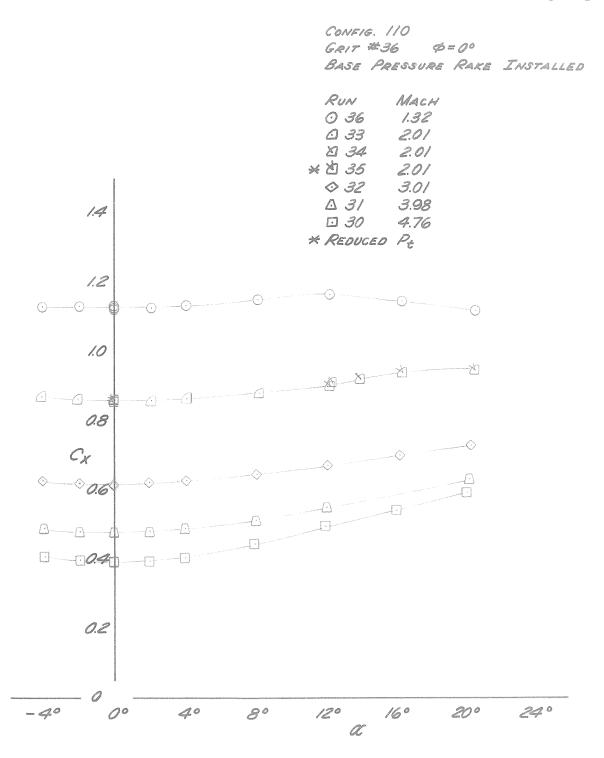
3.98

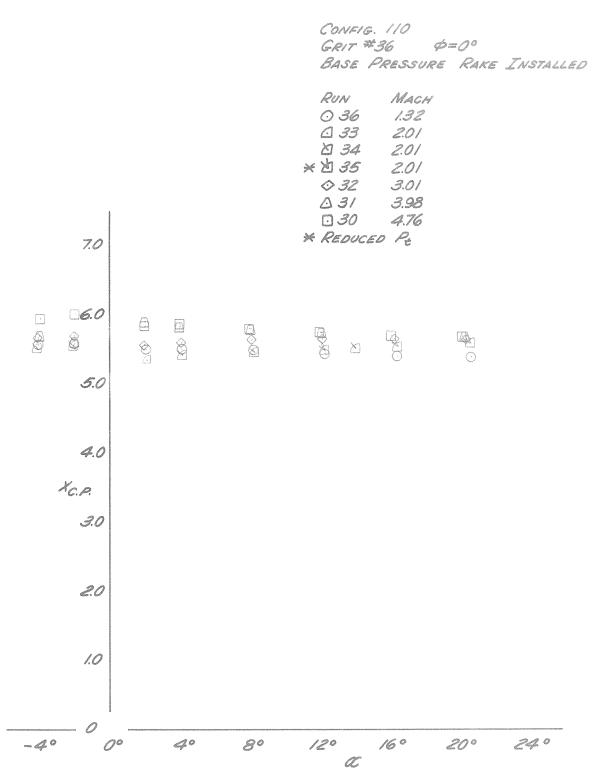
□ 30 4.76★ REDUCED P<sub>€</sub>

A 3/





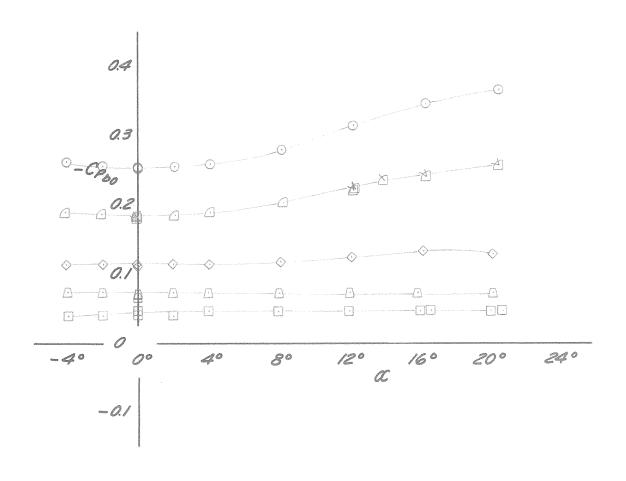




9 e

CONFIG. 110
GRIT #36 \$\phi = 0^\circ}
BASE PRESSURE RAKE INSTALLED

RUN MACH 0 36 1.32 0 33 2.01 D 34 2.01 2.01 × 凶 35 ♦ 32 3.01 A 31 3.98 O 30 4.76 \* REDUCED Pt



SNT 20-308

CONFIG. 010 GRIT = NONE \$=0°

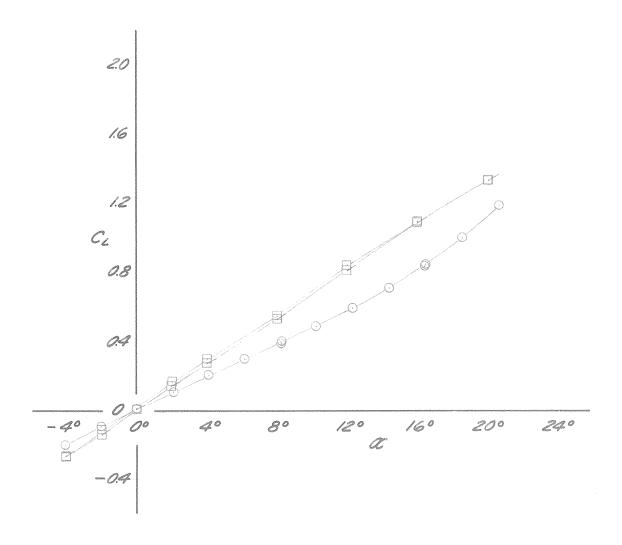
RUN MACH

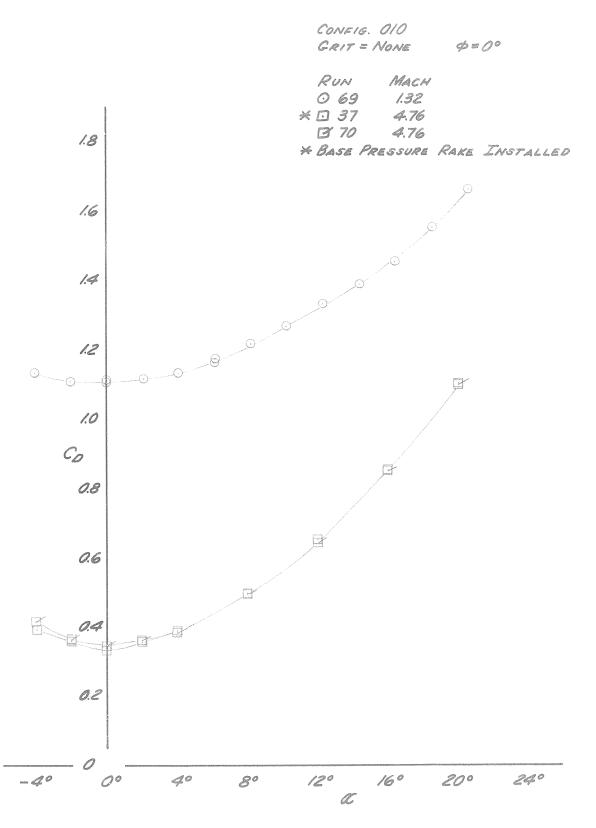
○ 69 1.32

\* □ 37 4.76

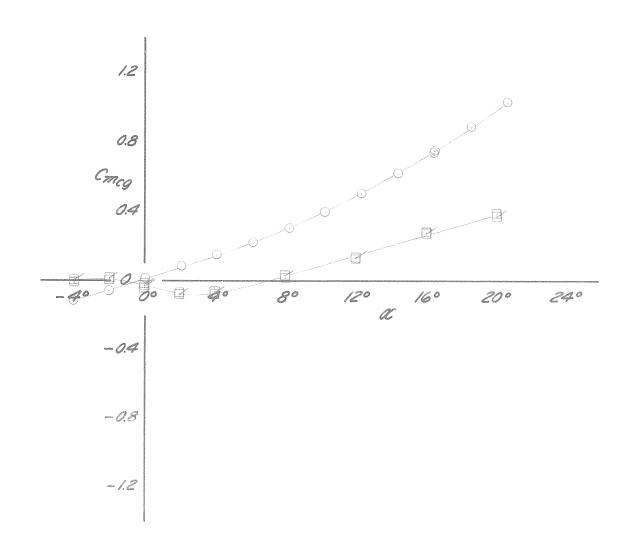
□ 70 4.76

\* BASE PRESSURE RAKE INSTALLED





\* BASE PRESSURE RAKE INSTALLED

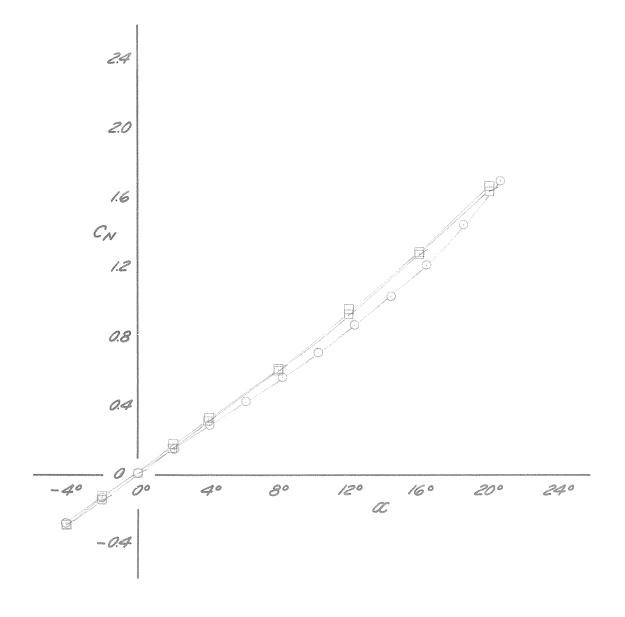


CONFIG. 010
GRIT = NONE \$\phi = 0^\circ\$

RUN MACH

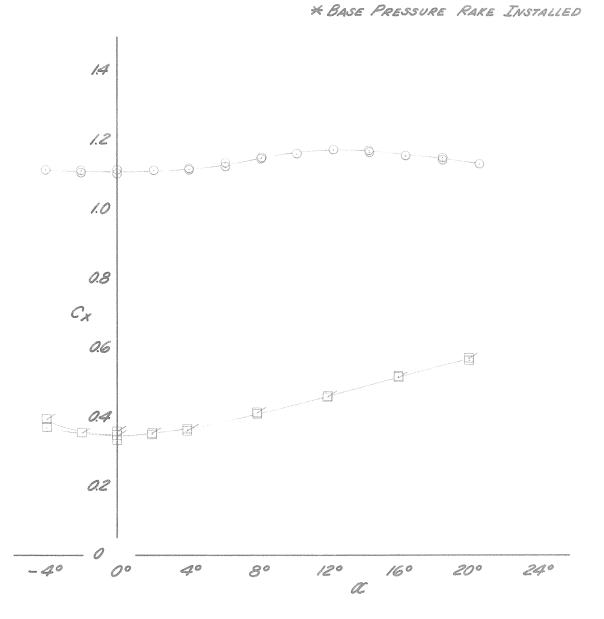
○ 69 /.32 \* □ 37 4.76 □ 70 4.76

\* BASE PRESSURE RAKE INSTALLED



CONFIG. 010
GRIT = NONE \$\phi = 0^\circ

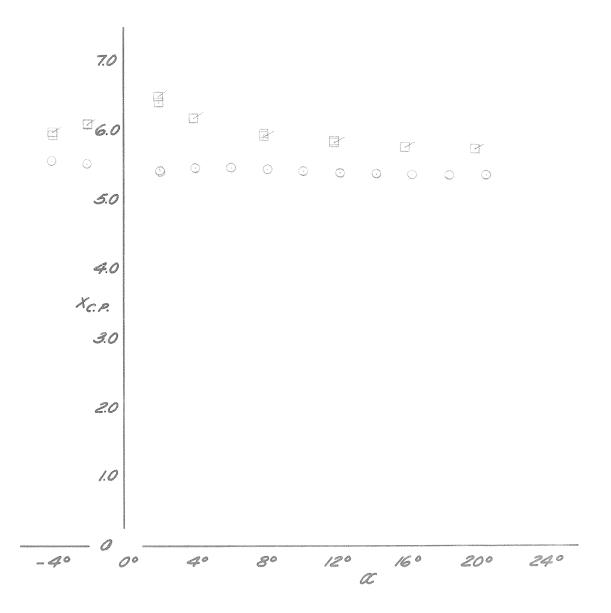
RUN MACH
0 69 1.32
\* \overline{1} 37 4.76
\overline{2} 70 4.76



0 d

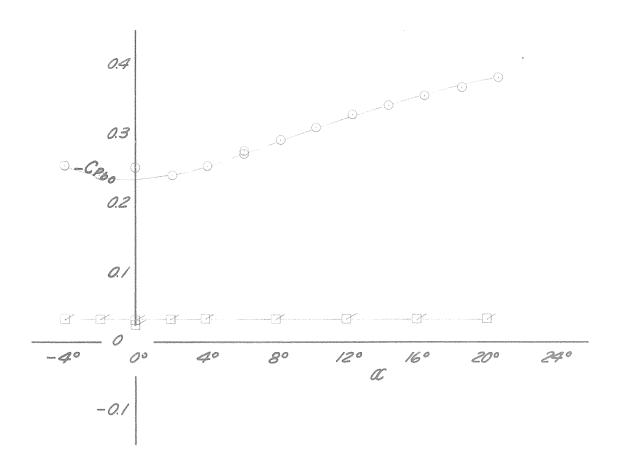
SMT 20-308

\* BASE PRESSURE RAKE INSTALLED



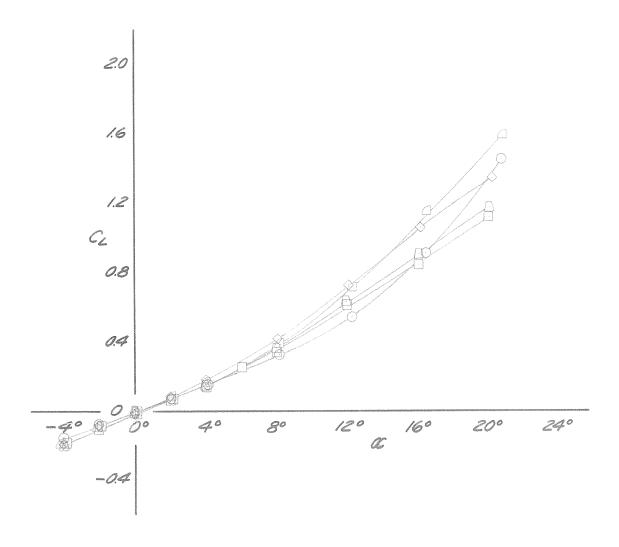
SNT 20-308

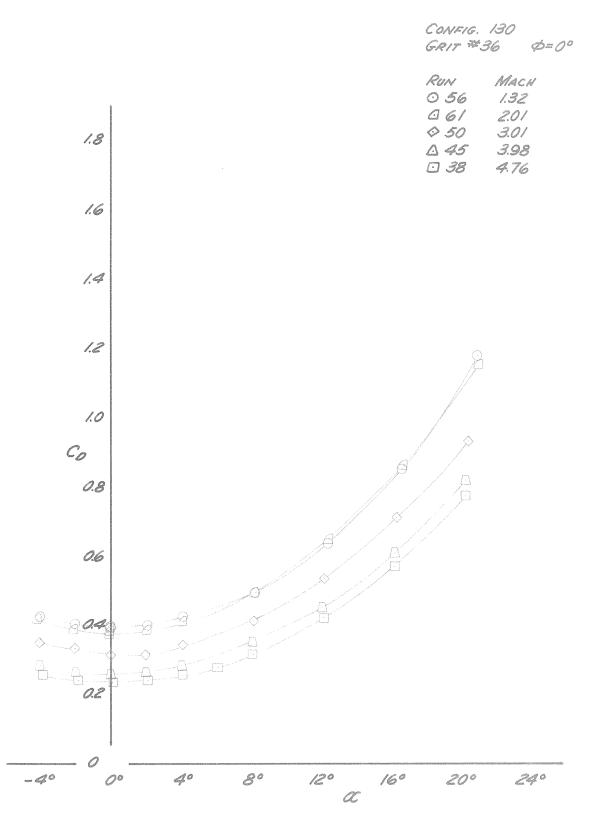
\* BASE PRESSURE RAKE INSTALLED



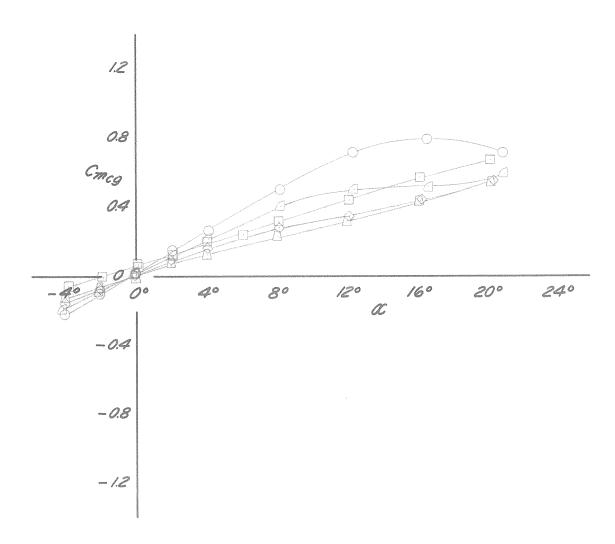
-304

CONFIG. GRIT #	-
RUN	MACH
0 56 0 61	1.32 2.01
<i>\$ 50</i> ∆ <i>45</i>	3.01 3.98
D 38	4.76

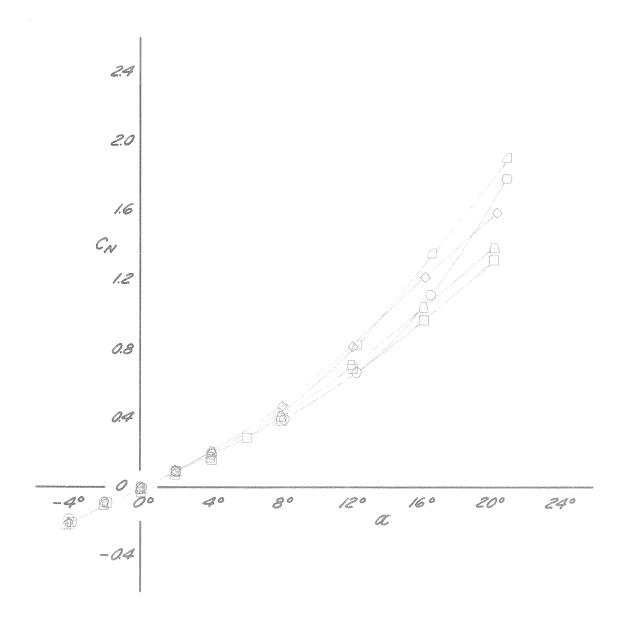


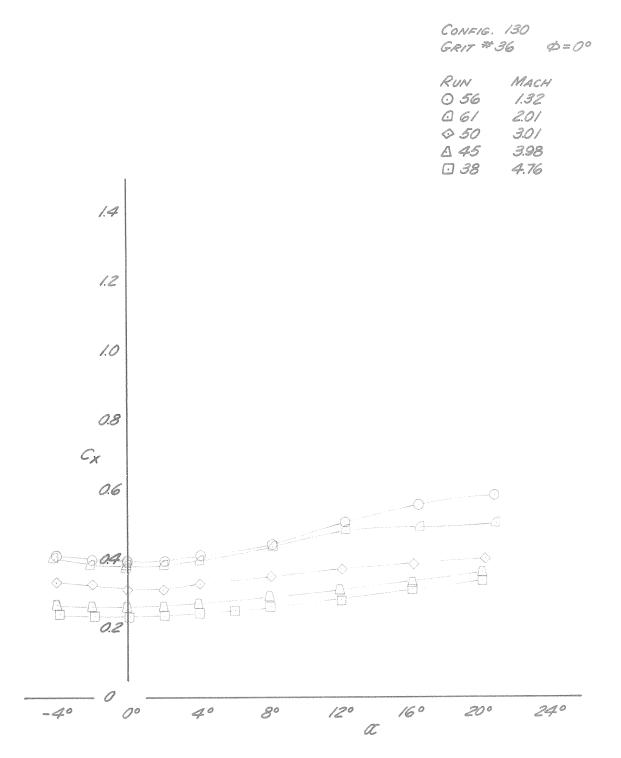


CONFIG.	130	
GRIT #.	36	\$=0°
RUN	MAC	H
0 56	1.32	2
061	2.01	/
O 50	3.01	/
A 45	3.98	3
O 38	4.76	5



CONFIG	. 130	
GRIT #	±36	Ø=0°
RUN	Ma	CH
0 56	1.3	2
061	2.0	7/
♦ 50	3.0	7/
A 45	3.9	8
D 38	4.7	6





SMT 20-308

CONFIG. 130 GRIT #36 Ø=00 RUN MACH 0 56 1.32 061 2.01 0 50 3.01 A 45 3.98 0 38 4.76 7.0 6.0 **4 2 2** ∆5.0 ∂ 4.0 XC.P. 3.0 2.0

120

Œ

160

20°

PLOT 316

240

10

1.0

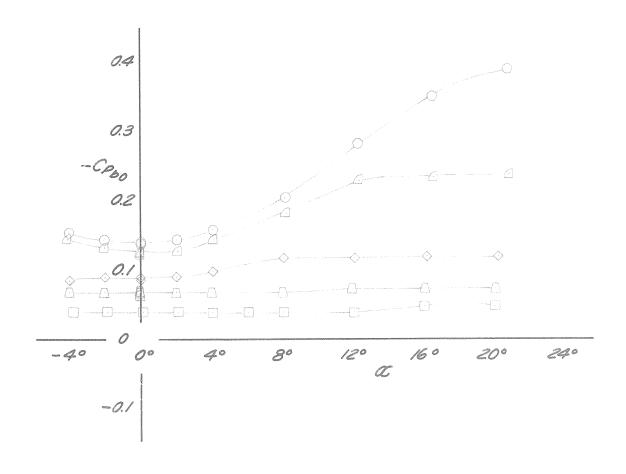
-40

00

40

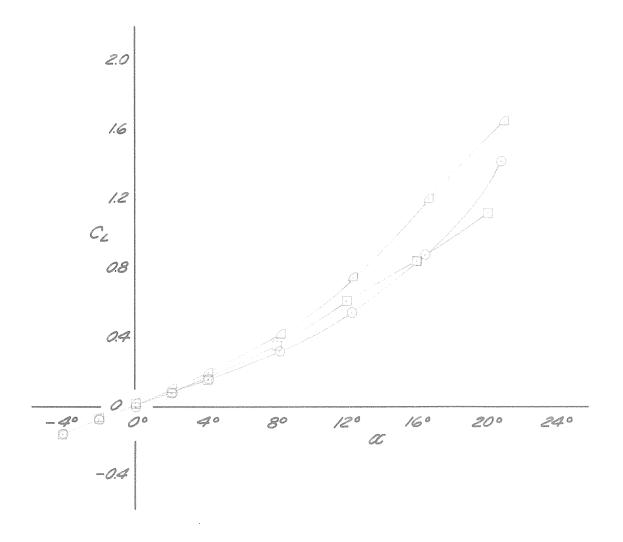
80

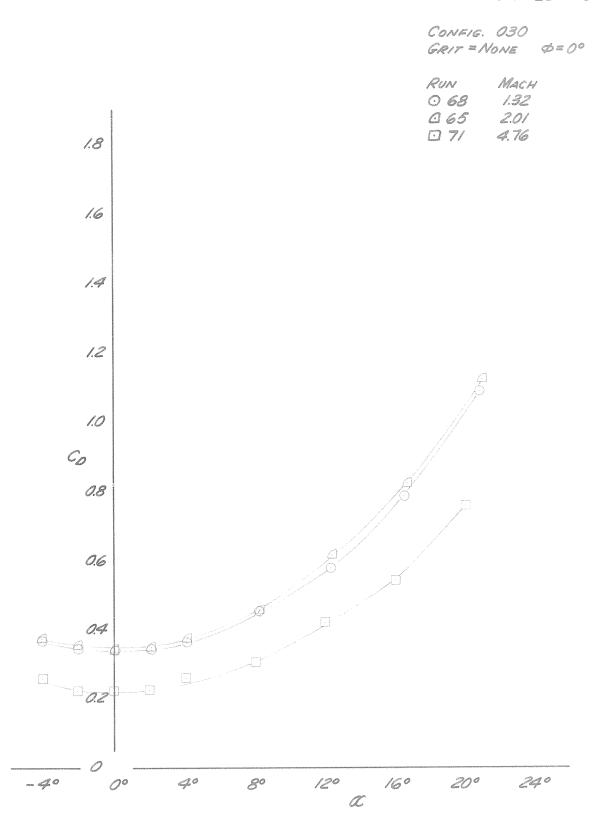
CONFIG	130	
GRIT #	36	Ø=0°
RUN	MA	CH
0 56	1.3	12
061	2.0	7/
Ø 50	3.0	)/
A 45	3.5	18
O 38	4.7	6



CONFIG. 030 GRIT = NONE \$=0°

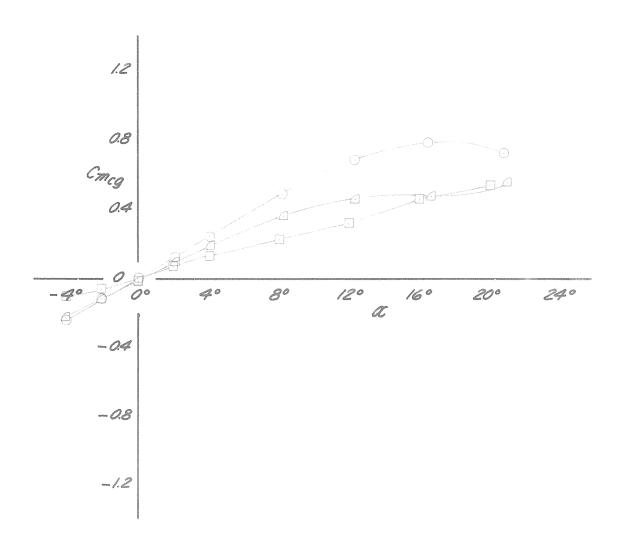
RUN MACH 0 68 1.32 0 65 201 0 71 4.76



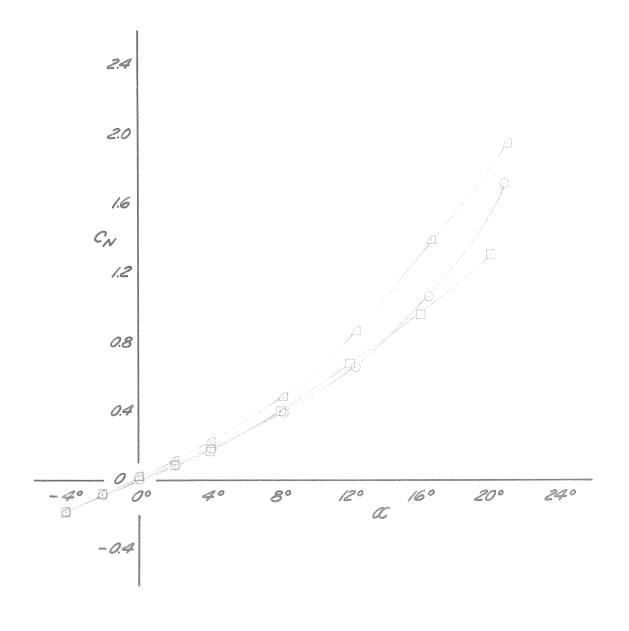


CONFIG. 030 GRIT = NONE \$=0°

RUN MACH 0 68 1.32 0 65 201 0 71 4.76

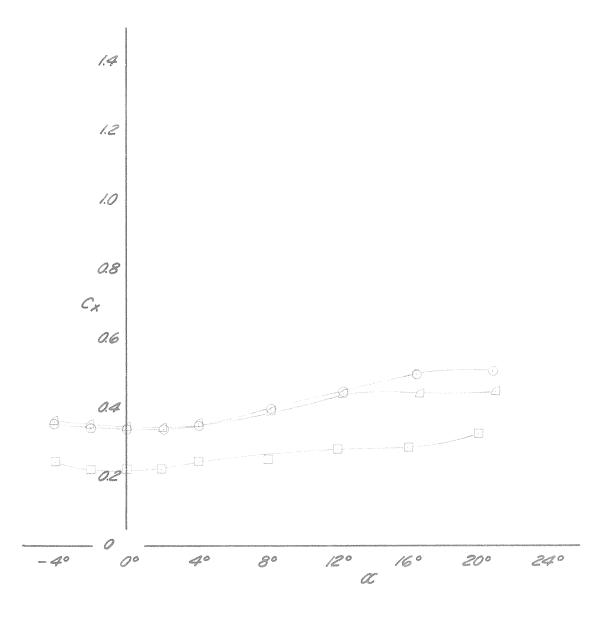


CONFIG. 030 GRIT = NONE \$=0°



CONFIG. 030 GRIT = NONE \$5=00

RUN MACH 0 68 1.32 0 65 2.01 1 71 4.76



CONFIG. 030 GRIT = NONE \$=0°

RUN MACH
0 68 1.32
0 65 2.01
0 71 4.76

7.0 6.0 08 0 93 5.0 8 0 0 XC.P. 3.0 2.0 1.0 00 240 160 200 40 80 120 -40 Œ

CONFIG. 030
GRIT = NONE \$\Phi = 0^\circ\$

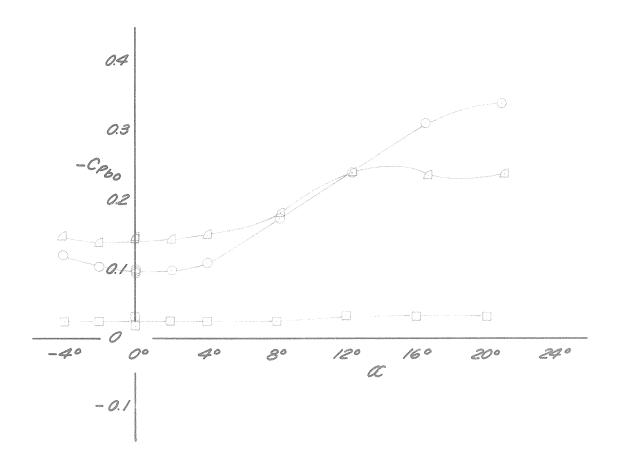
RUN MACH

0 68 1.32

0 65 201

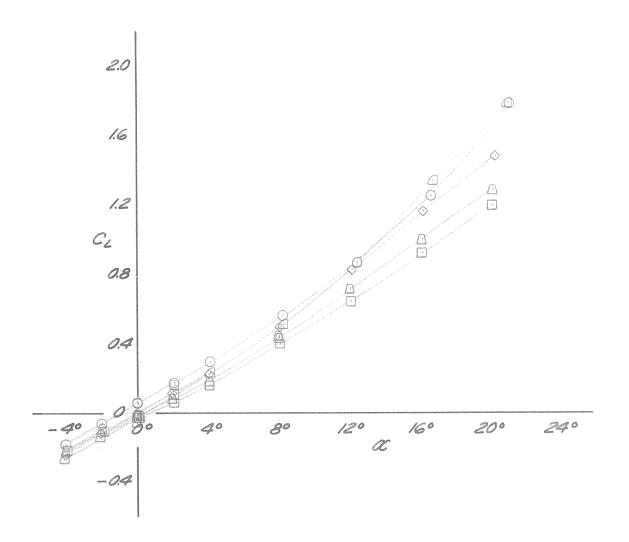
4.76

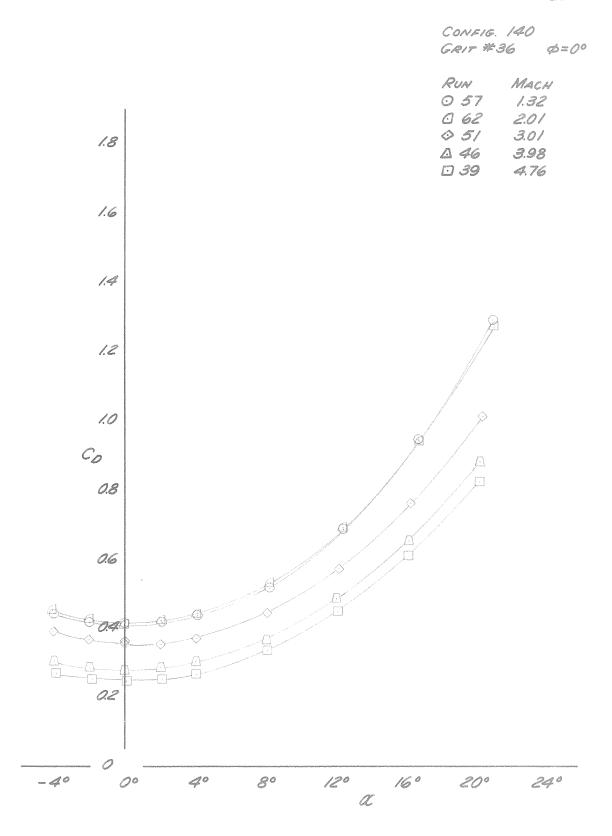
0 7/



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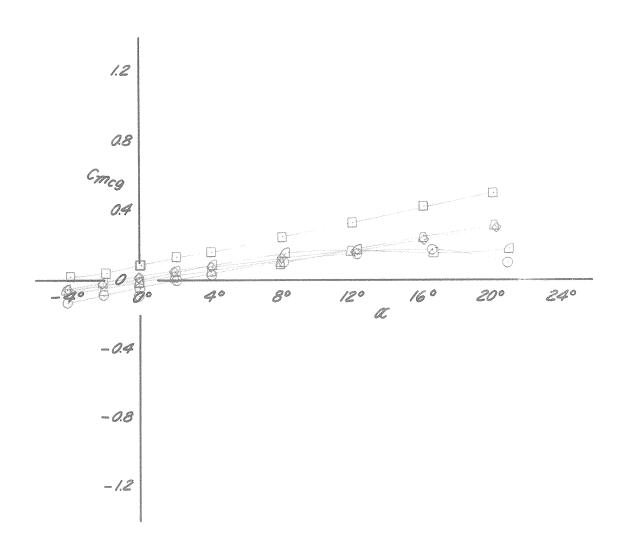
CONFI	G. 140	
GRIT	#36	\$=0°
RUN	MACH	
057	1.32	
0 62	2.01	
051	3.01	
D 46	3.98	
□ 39	4.76	



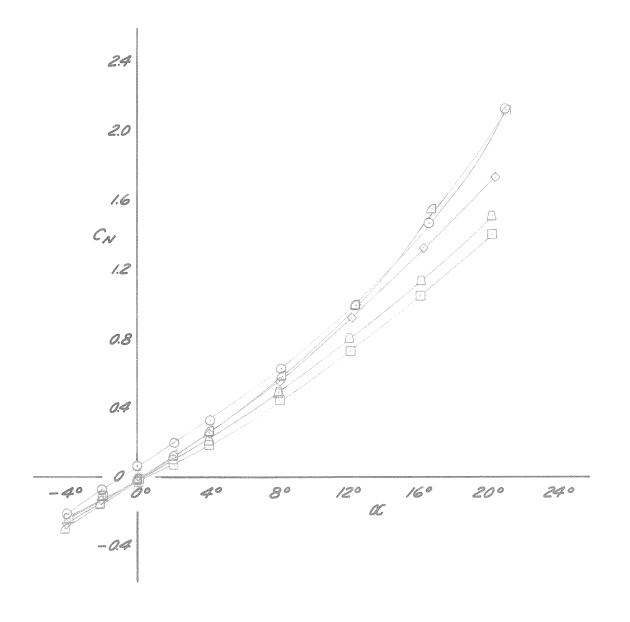


SNT 20-308

CONFIG.	140
GRIT #	36 Ø=0°
RUN	MACH
057	1.32
0 62	2.01
Ø 51	3.01
A 46	3.98
D 39	4.76



CONFI	G. 140	
GRIT	#36	\$=0°
RUN	MAG	CA .
057	1.32	2
0 62	2.01	/
\$ 51	3.01	/
A 46	3.98	3
O 39	4.76	5

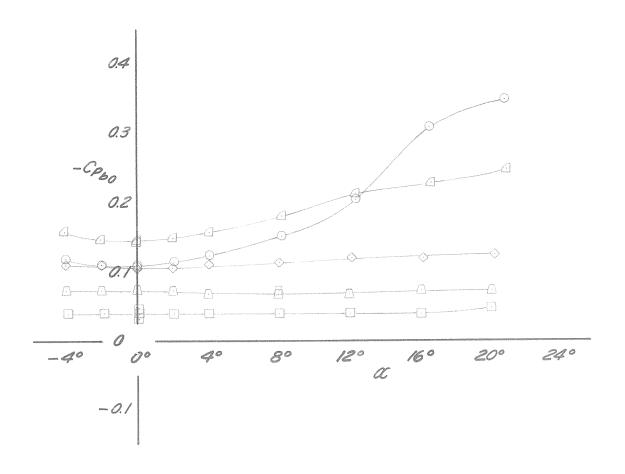


SNT 20-308

					CONFIG.	. 140 36 \$=0°
	1.4				Run 0 57 0 62 0 51 0 46 0 39	MACH 1.32 2.01 3.01 3.98 4.76
	1.2					
	1.0					
0	0.8					
	0.6			G		
	0.2					
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				Œ		

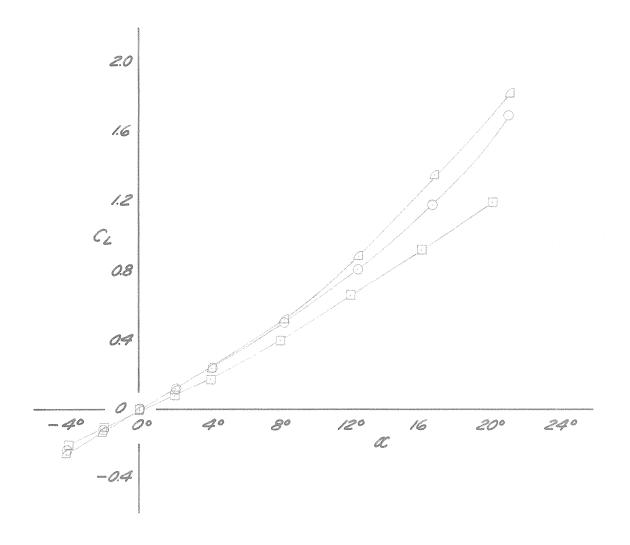
							CONFIG. GRIT #3	140 36
							RUN ○ 57 △ 62 ◆ 51 △ 46 □ 39	MACH 1.32 2.01 3.01 3.98 4.76
	7.0							
	6.0							
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0	\(\text{\text{\sigma}}\)	선				Lil	benigali	
			O					
	4.0							
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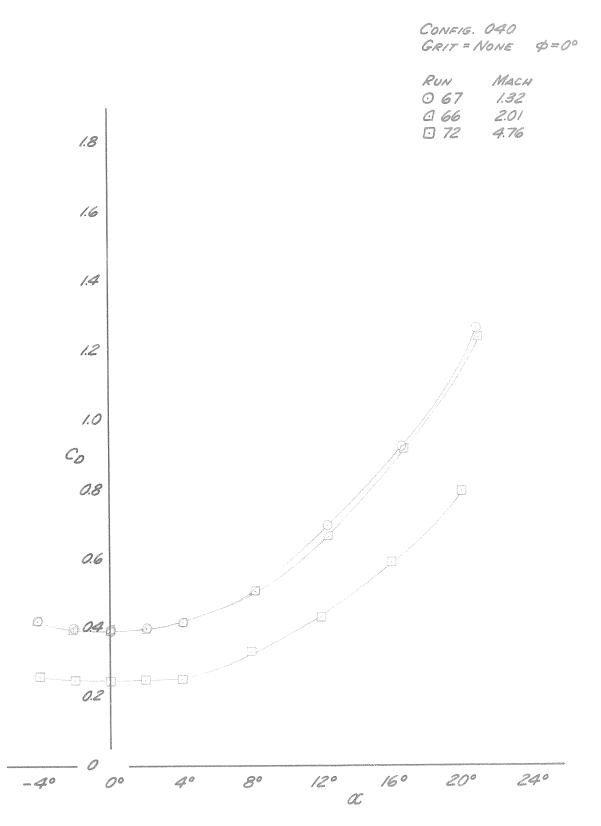
CONFIG.	140	
GRIT #	36	Ø=00
RUN	MAC	î.H
057	1.3	2
062	2.0	/
051	3.0	/
A 46	3.9	8
O 39	4.76	ś



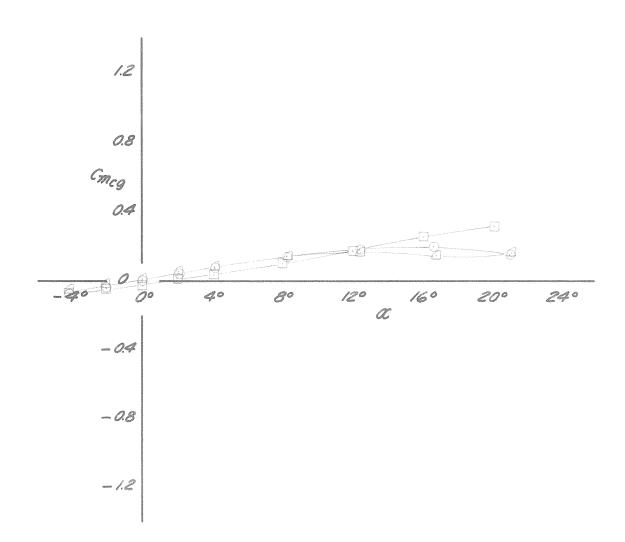
SMT 20-308

CONFIG. 040 GRIT = NONE \$=00

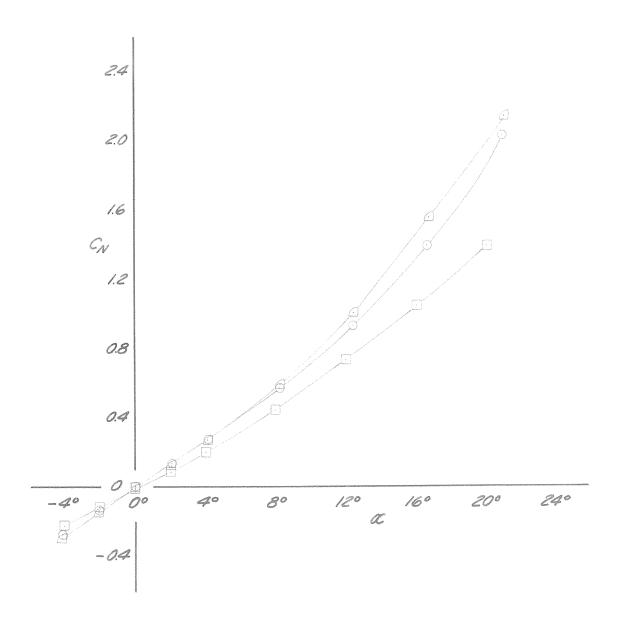




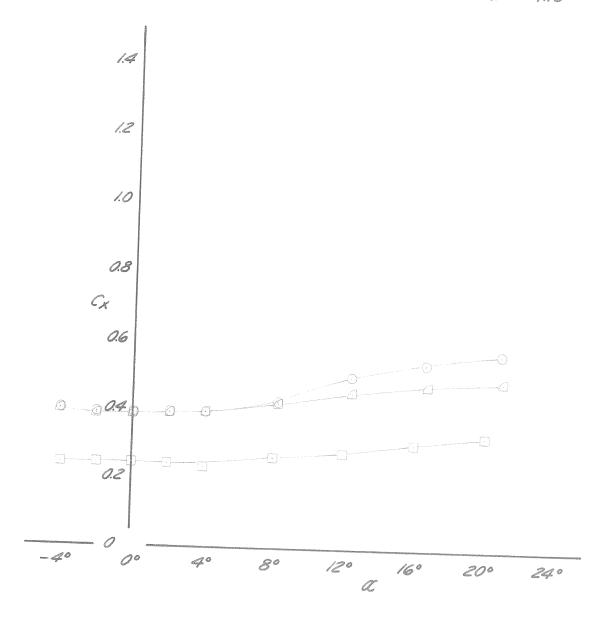
CONFIG. 040 GRIT = NONE \$\phi = 0^\circ\$



CONFIG. 040
GRIT = NONE \$\phi = 0^\circ\$

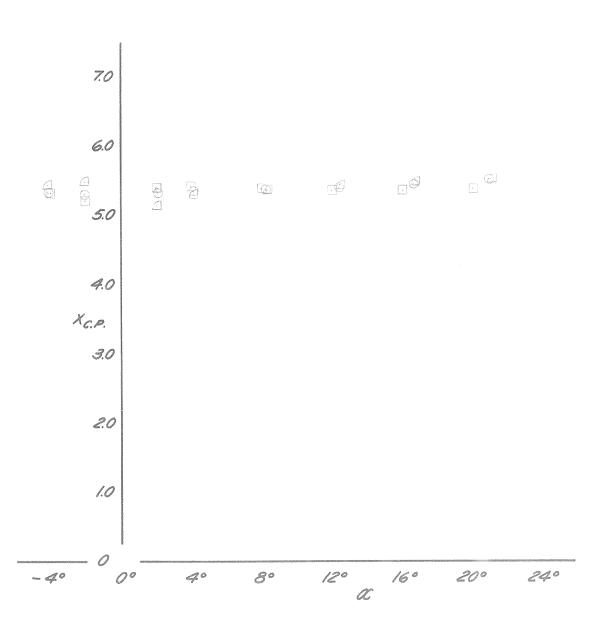


CONFIG. 040 GRIT = NONE \$5=00



SNT 20-308

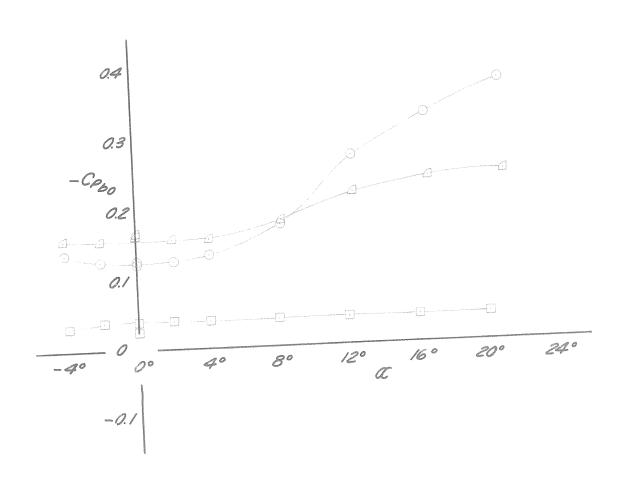
CONFIG. 040 GRIT = NONE \$\phi = 0^\circ\$



CONFIG. 040
GRIT = NONE \$\Phi = 0^\circ\$

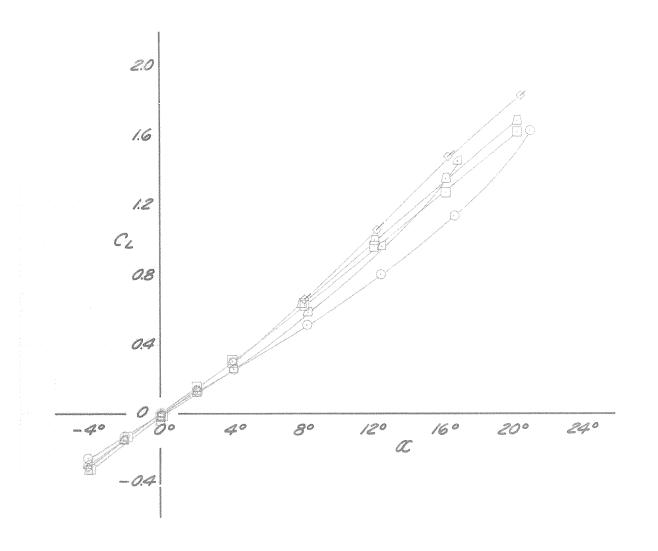
RUN MACH

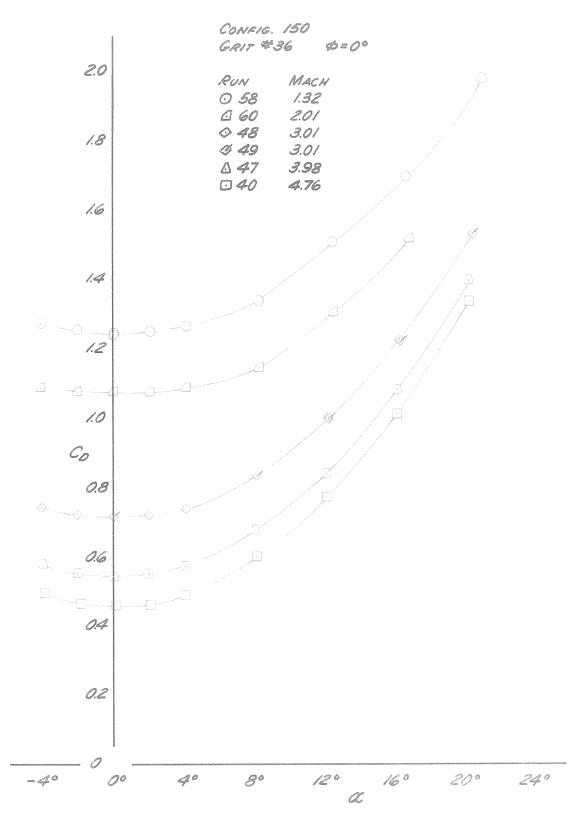
0 67 1.32 0 66 2.01 0 72 4.76



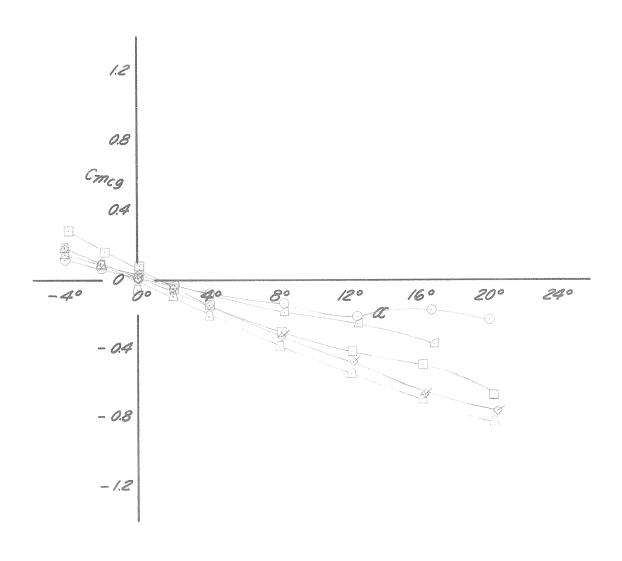
74 £

-	ONFIG.		φ=0°
R	UN	MACH	,
0	58	1.32	
	60	2.01	
0	48	3.01	
0	49	3.01	
Δ	47	3.98	
ſ.	40	476	

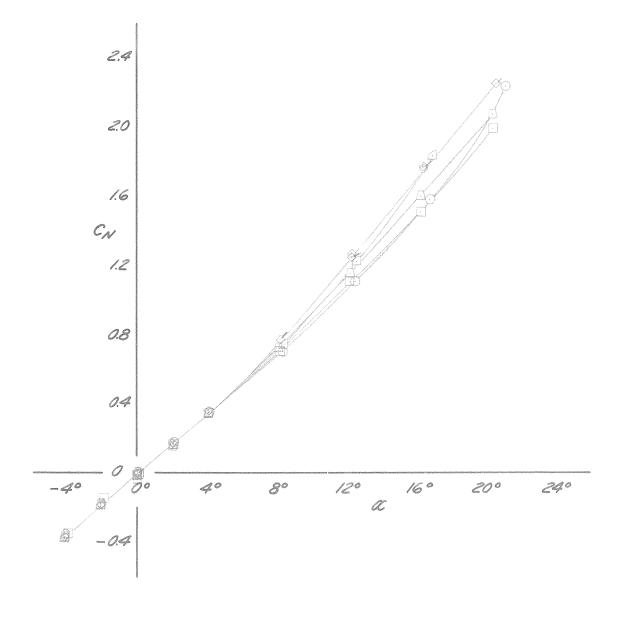




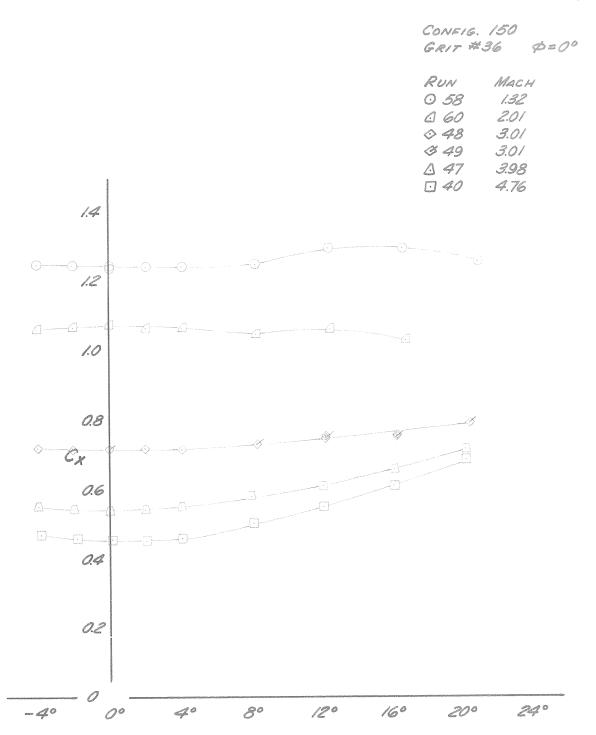
CONFI	G. 150	
GRIT	#36	Ø=0°
RUN	MAC	CH
0 58	1.32	2
0 60	2.01	/
O 48	3.01	/
Ø 49	3.0	/
0 47	3.98	3
040	4.76	5

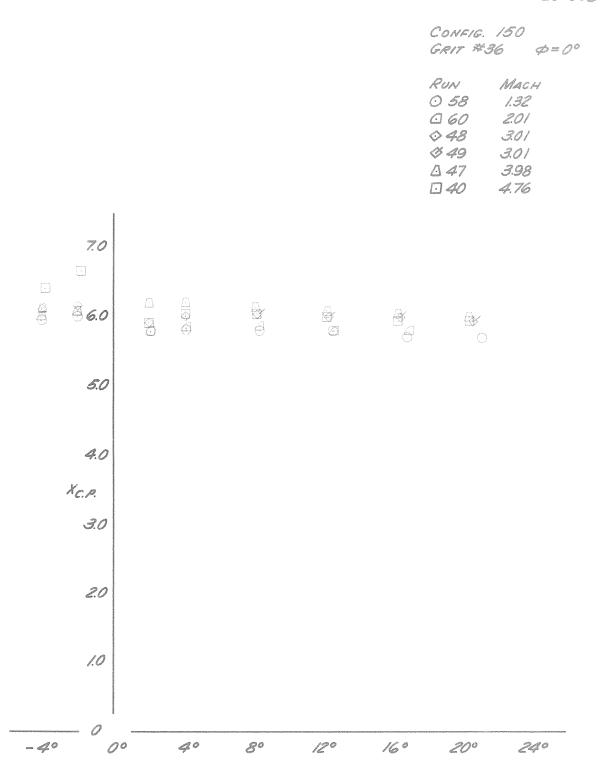


CONFI	rg. 150	
GRIT	#36	φ=0°
RUN	MA	CH
0 58	1.3	2
060	2.0	/
O48	3.0	/
\$49	3.0	/
047	3.9	3
040	4.70	6

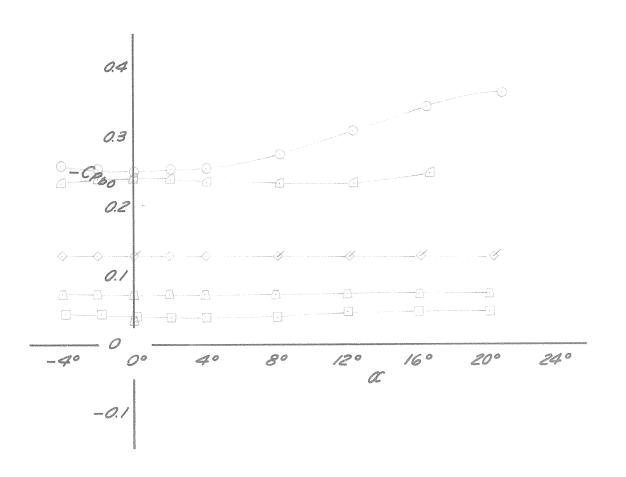


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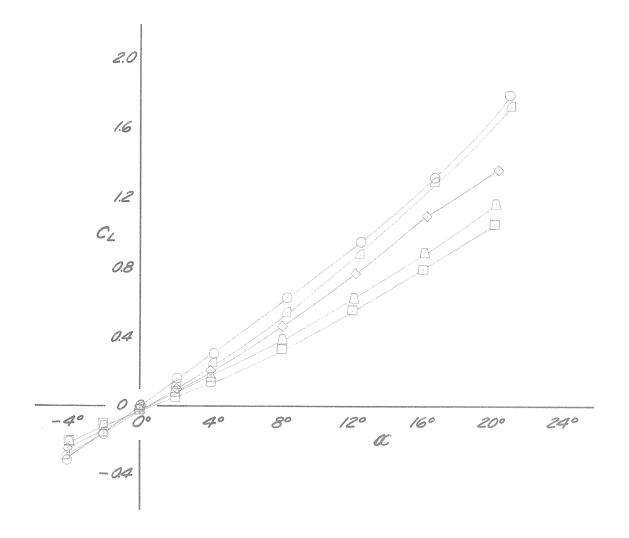


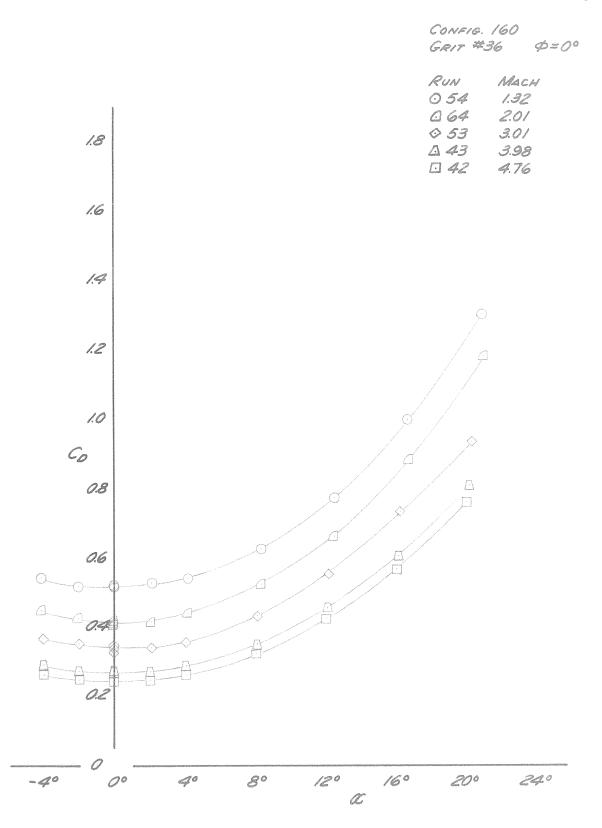
CONFI	g. 150	
GRIT	#36	Ø=00
RUN	MA	CH
0 58	1.3	2
060	2.0	/
O 48	3.0	/
349	3.0	/
047	3.9	3
0 40	4.7	6



SMT 20-308

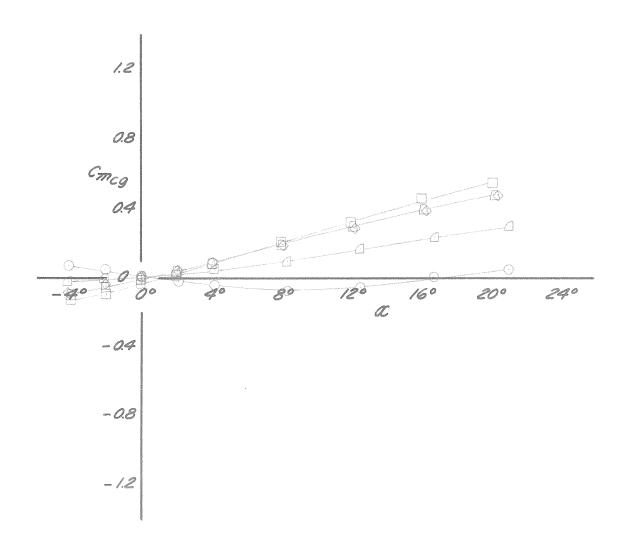
CONFI	G. 160	
GRIT	#36	Ø=0°
RUN	MAG	SH
0 54	1.3	
0 64	2.0	7
<i>♦ 53</i>	3.0	1
A 43	3.9	8
0 42	4.7	6



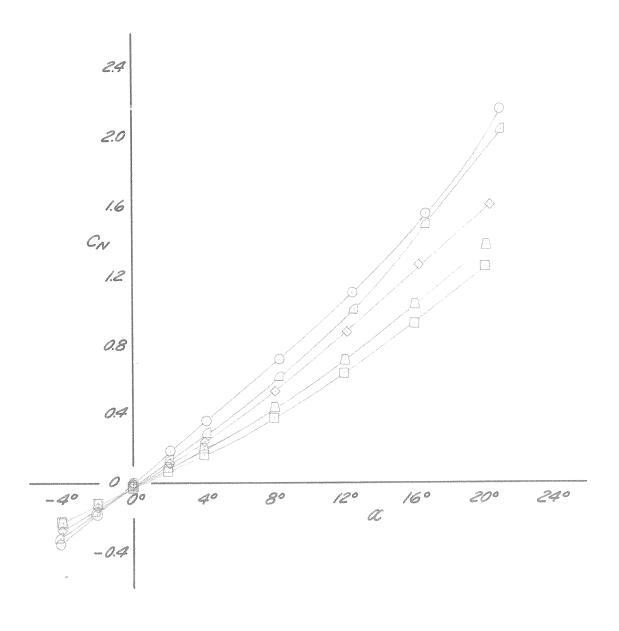


SMT 20-308

CONFIG. 1	60
GRIT #3	36 Ø=0°
RUN	MACH
0 54	1.32
0 64	2.01
♦ 53	3.01
∆ 43	3.98
0 42	4.76



CONFIG.	160
GRIT #	36 Ø=0°
RUN	MacH
054	1.32
0 64	2.01
O 53	3.01
A 43	3.98
0 42	4.76



						CONFIG. GRIT #.	160 36 \$=0°
14						RUN 0 54 0 64 0 53 0 43 0 42	MACH 1.32 2.01 3.01 3.98 4.76
7	None and the second sec						
1.2							
1.0							
0.8	P Control of the Cont						
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0.6							
0	<b>.</b>	. ag () junganasan 1 / 100 h 1 / 1 = 1/			()	0	
4		0					
			a consistent of the second	and the second s			
0.2				0			
0	00	40	80	120	16°3	20°	240
				Œ			

		6	CONFIG. GRIT #	160 36 Ø=0°
		4	RUN 0 54 0 64 0 53 0 43 0 42	MACH 1.32 2.01 3.01 3.98 4.76
7.0				
6.0			9	
4.0 X <sub>C.P.</sub> 3.0				
2.0				
1.0				

12°

80

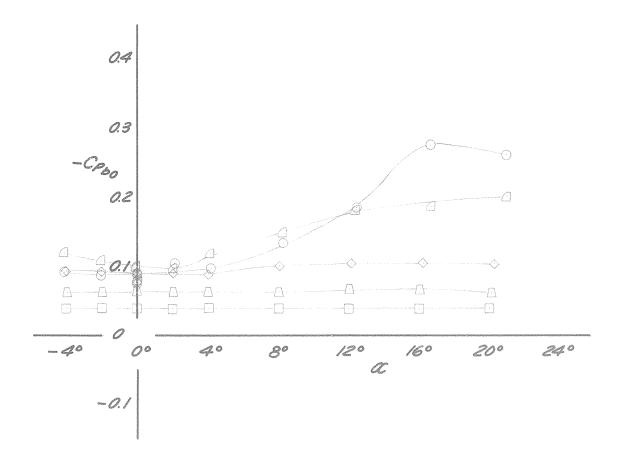
160

200

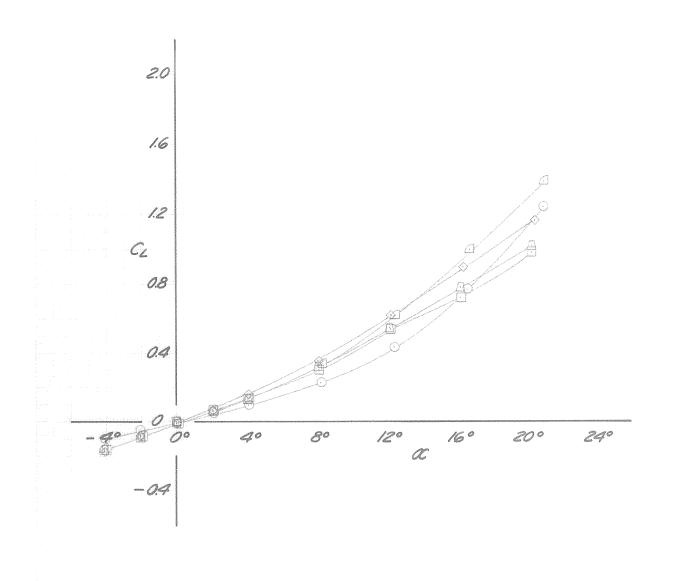
240

SNT 20-308

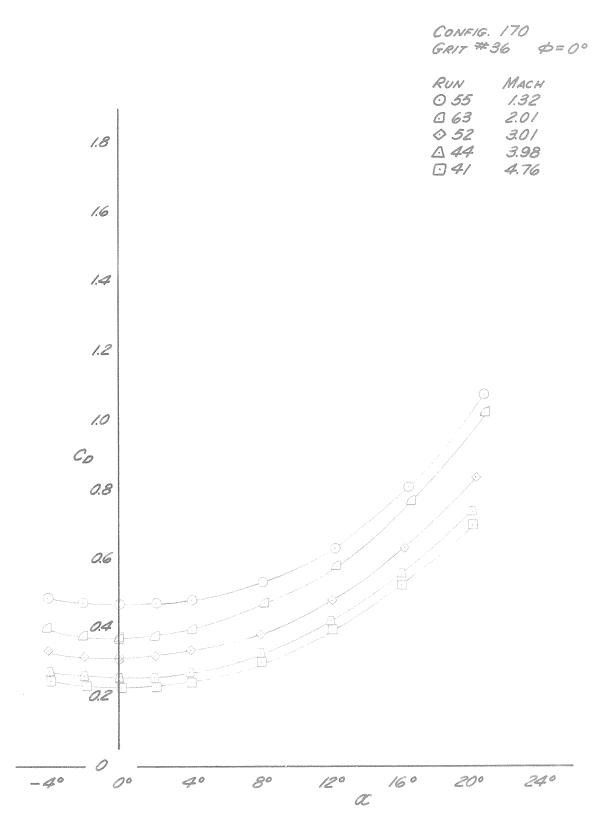
CONFI	G. 160	
GRIT	#36	Ø=0°
RUN	MA	CH
054	1.3.	La.
0 64	2.0	/
Q 53	3.0	/
043	3.90	8
0 42	4.70	6



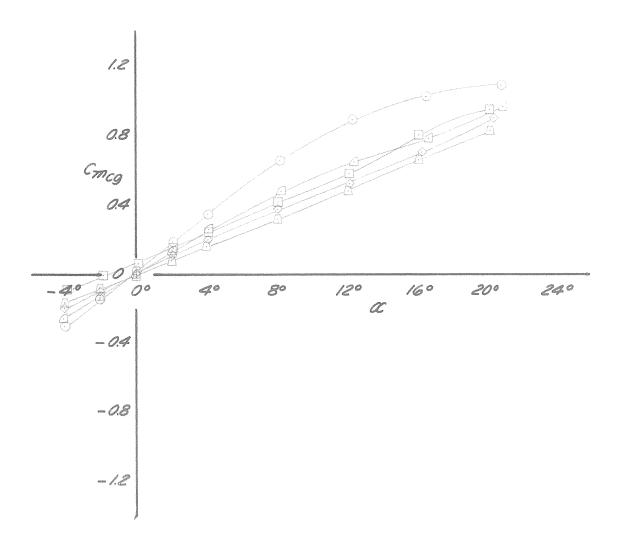
CONFI	G. 170 #36	φ=0°
RUN	Mack	-
0 55	1.32	*
△ 63 ◇ 52	2.01 3.01	
A 44	3.98 2.76	



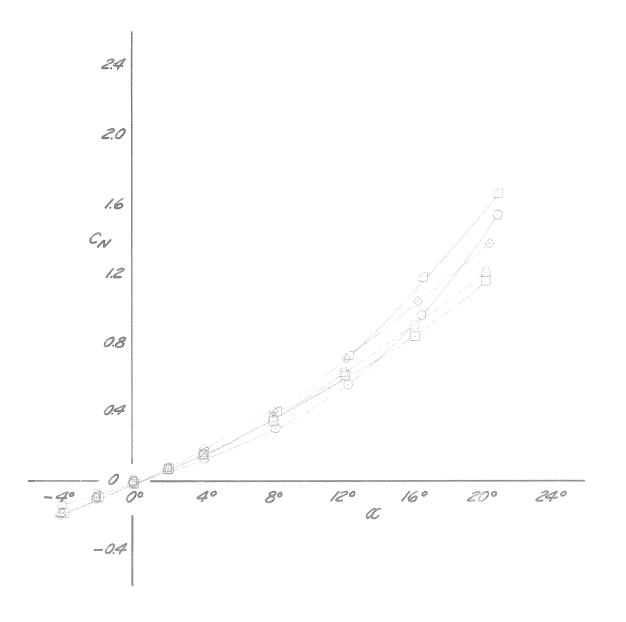
SNT 20-308



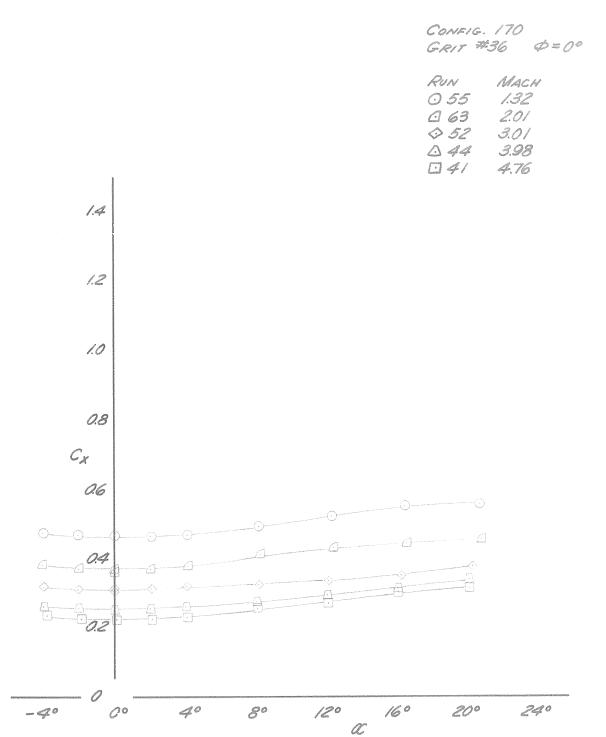
CONFIG.	170
GRIT #.	36 Ø=0°
RUN	MACH
0 55	1.32
0 63	2.01
O 52	3.01
0 44	3.98
04/	4.76

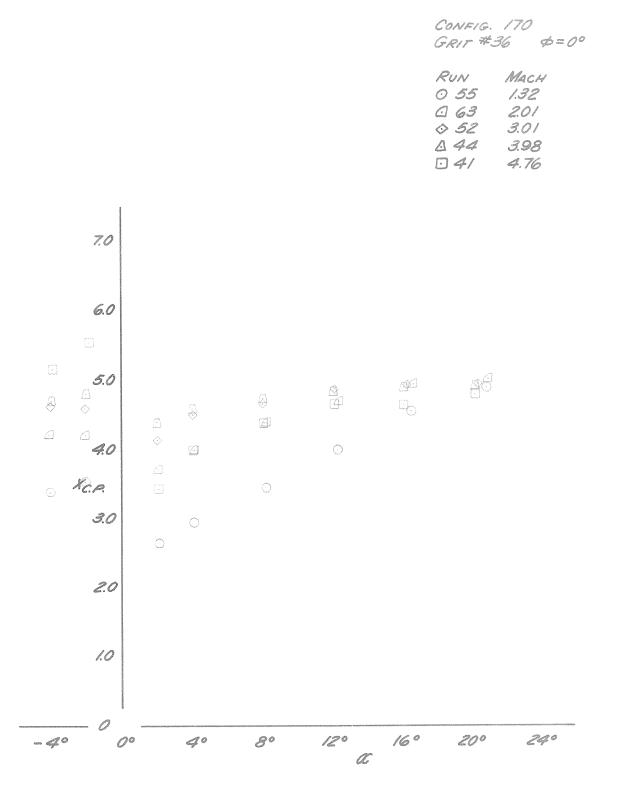


SMT 20-308

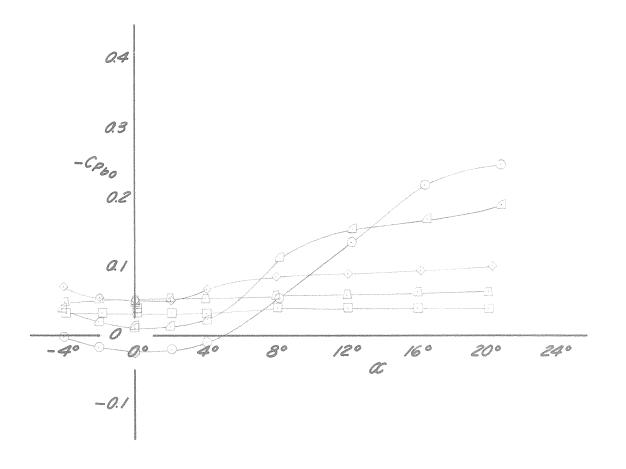


37C





CONFI	G. 170	
GRIT	#36	\$=0°
RUN	MAC	H
0 55	1.32	2
0 63	2.0	/
0 52	3.0	/
044	3.90	9
041	4.70	5



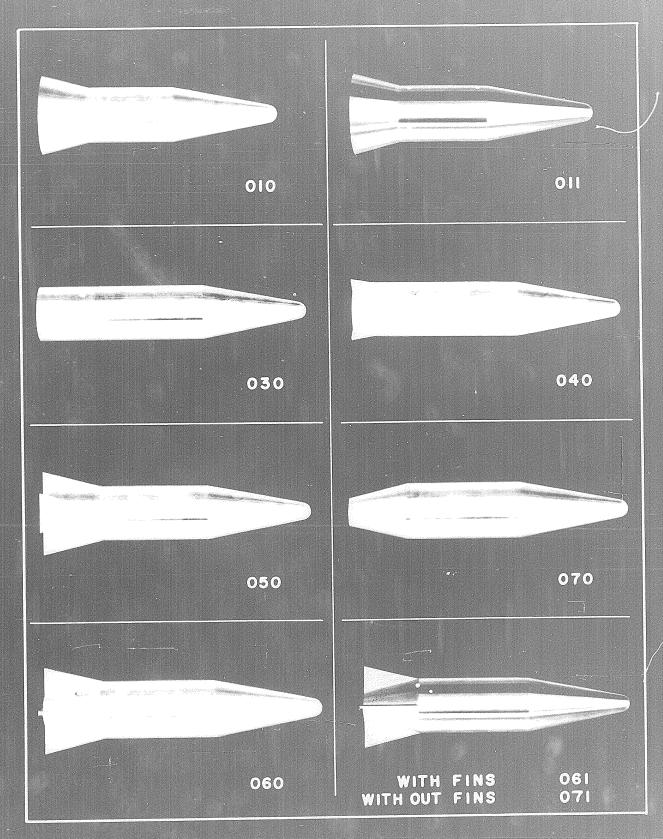


FIGURE I.

VARIOUS MODELS TESTED

SECRET

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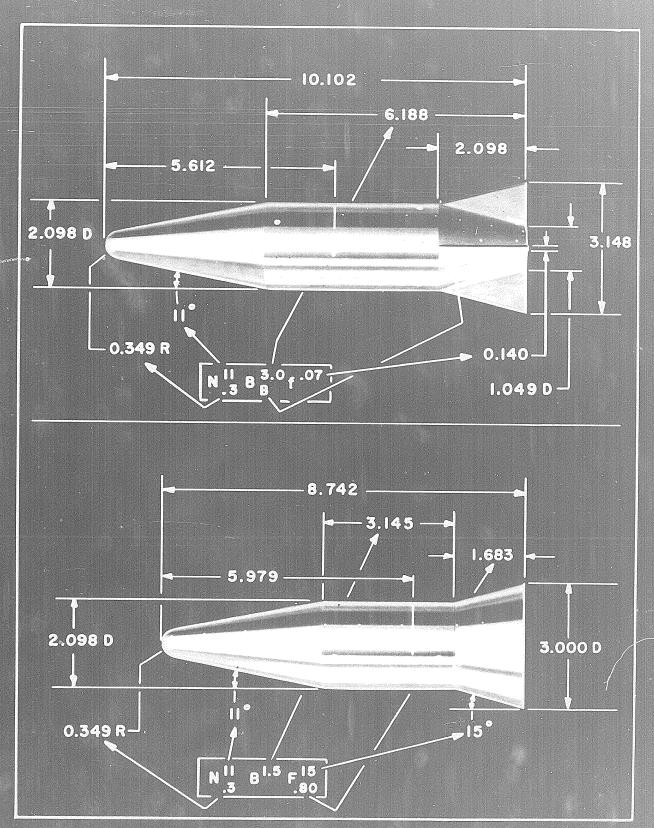


FIGURE 2. MODEL DIMENSIONS AND CONFIGURATION NOMENCLATURE

SECRET

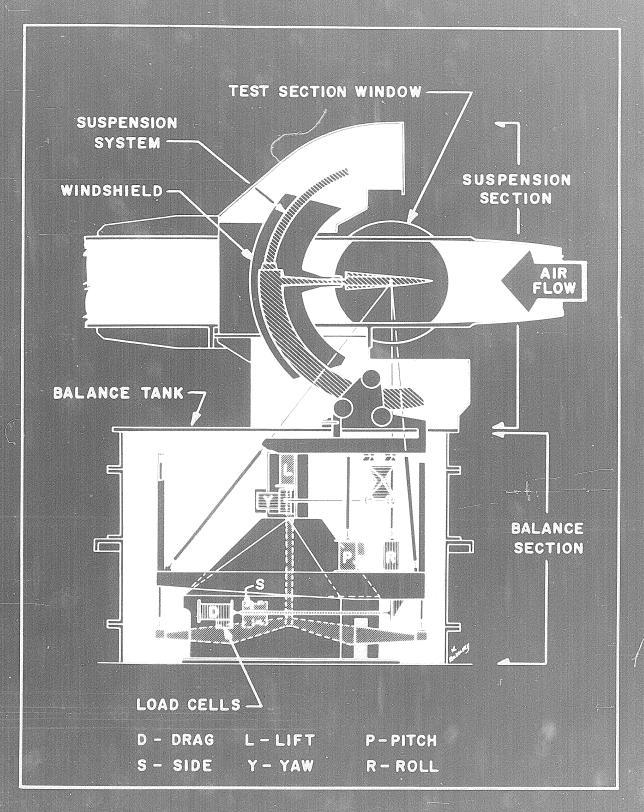
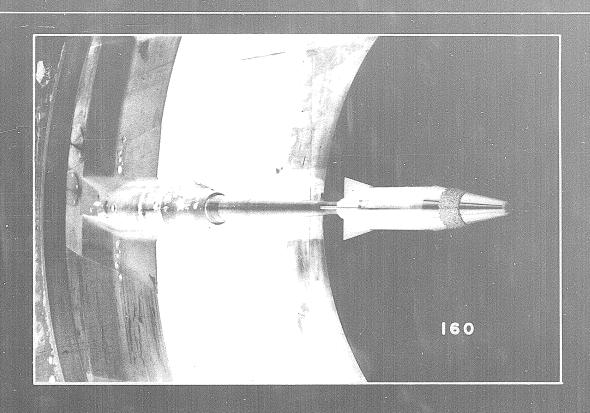


FIGURE 3. THE SIX-COMPONENT EXTERNAL BALANCE
AND SUPPORT SYSTEM



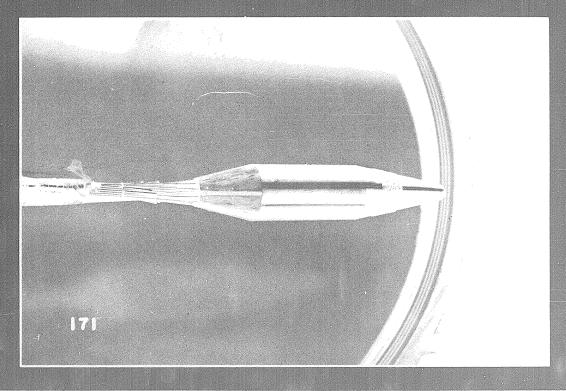


FIGURE 4. INSTALLATION OF MODEL CONFIGURATIONS 160 AND 171
SECRET

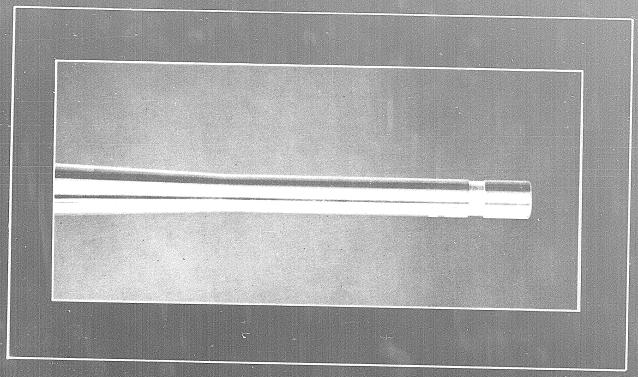


FIGURE 5.

MODEL SUPPORT STING

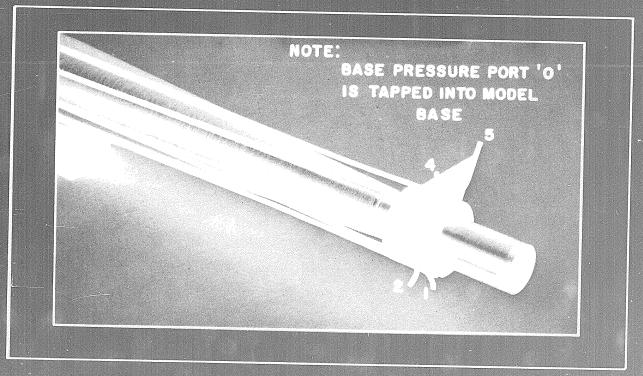


FIGURE 6.

BASE PRESSURE RAKE

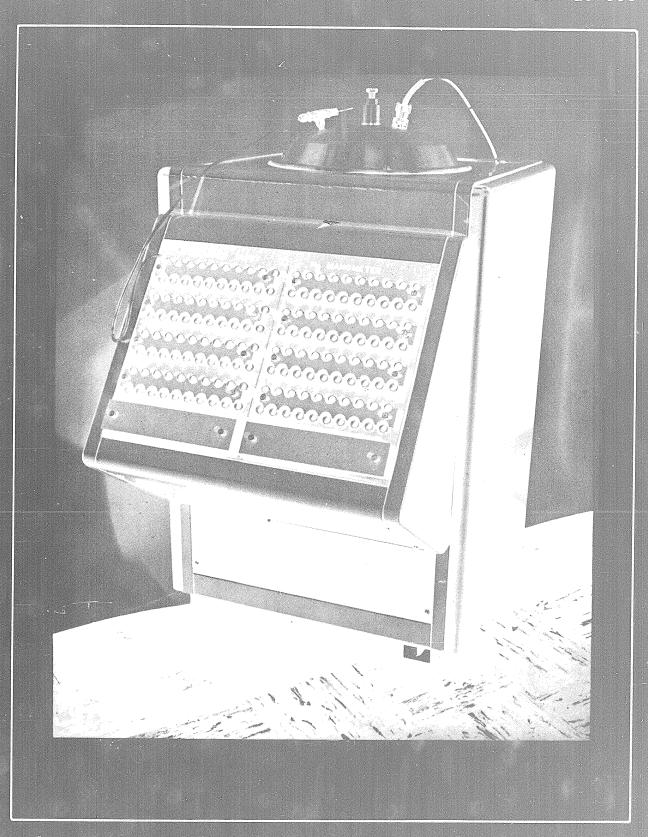


FIGURE 7.

MPMS SCANNER UNIT

SECRET

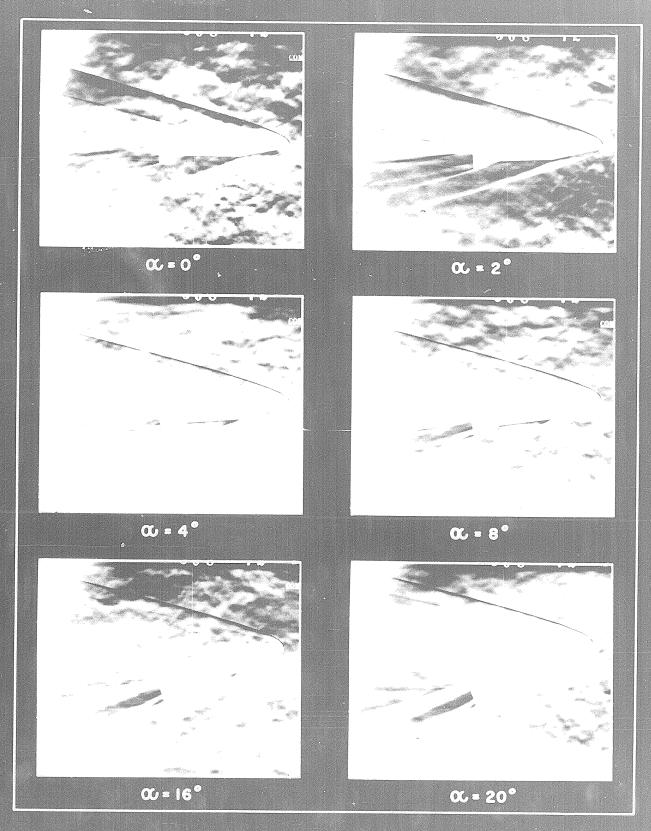


FIGURE 8. SCHLIEREN PHOTOS OF CONFIGURATION 040 AT M = 4.76
SECRET

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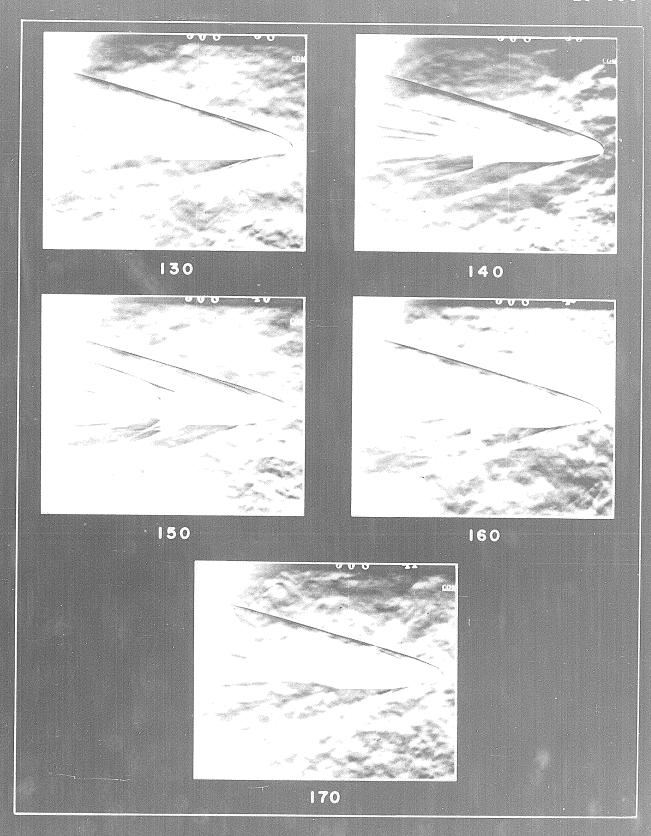


FIGURE 9. SCHLIEREN PHOTOS OF SEVERAL CONFIGURATIONS AT M = 4.76,  $CC = 0^{\circ}$  SECRET

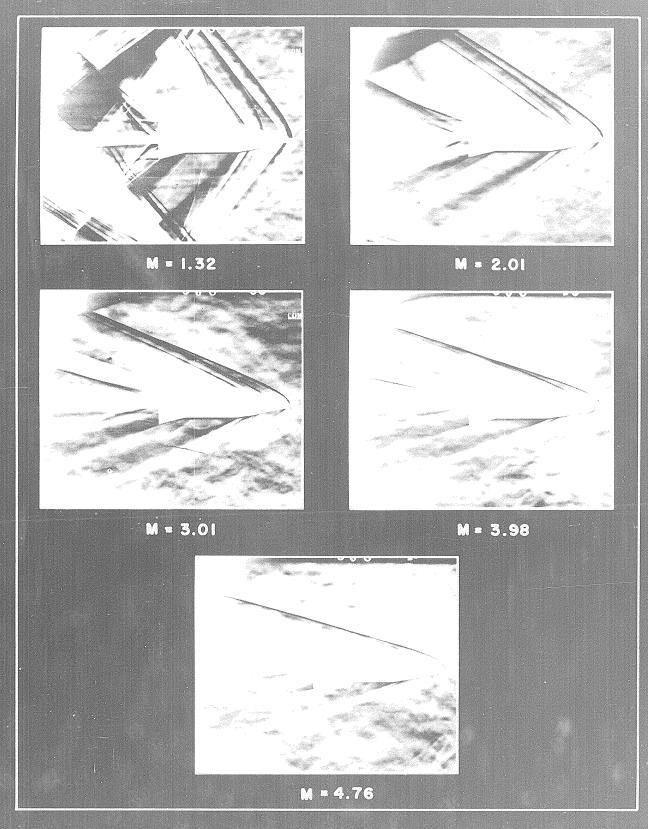


FIGURE 10. SCHLIEREN PHOTOS OF CONFIGURATION 160 AT FIVE MACH NUMBERS, OG = 0°

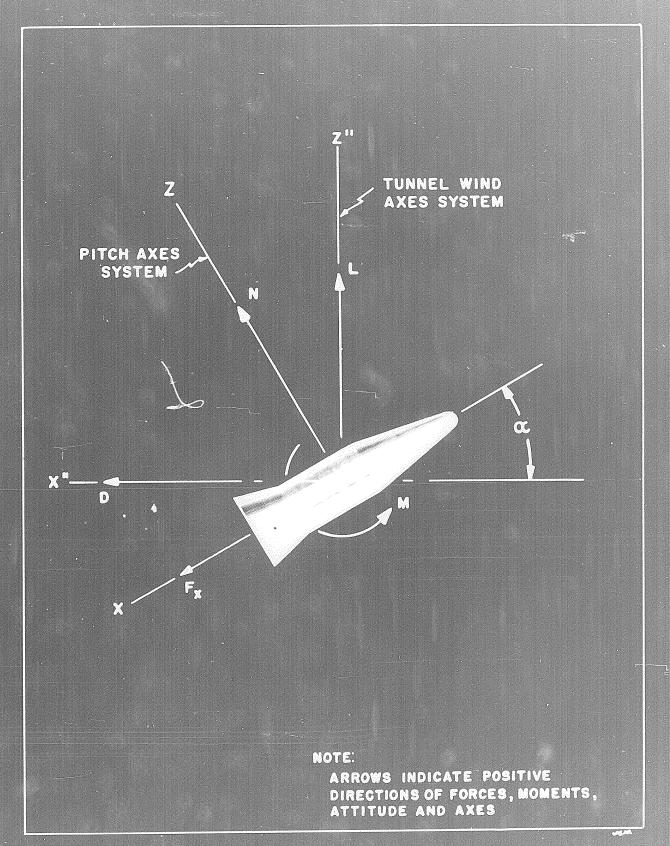


FIGURE II.

SIGN CONVENTIONS

SECRET